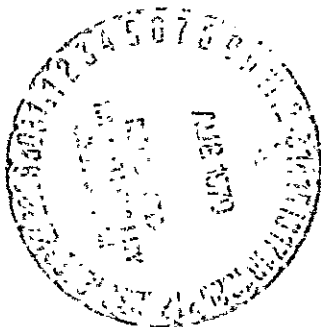


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SATURN S-IVB-209

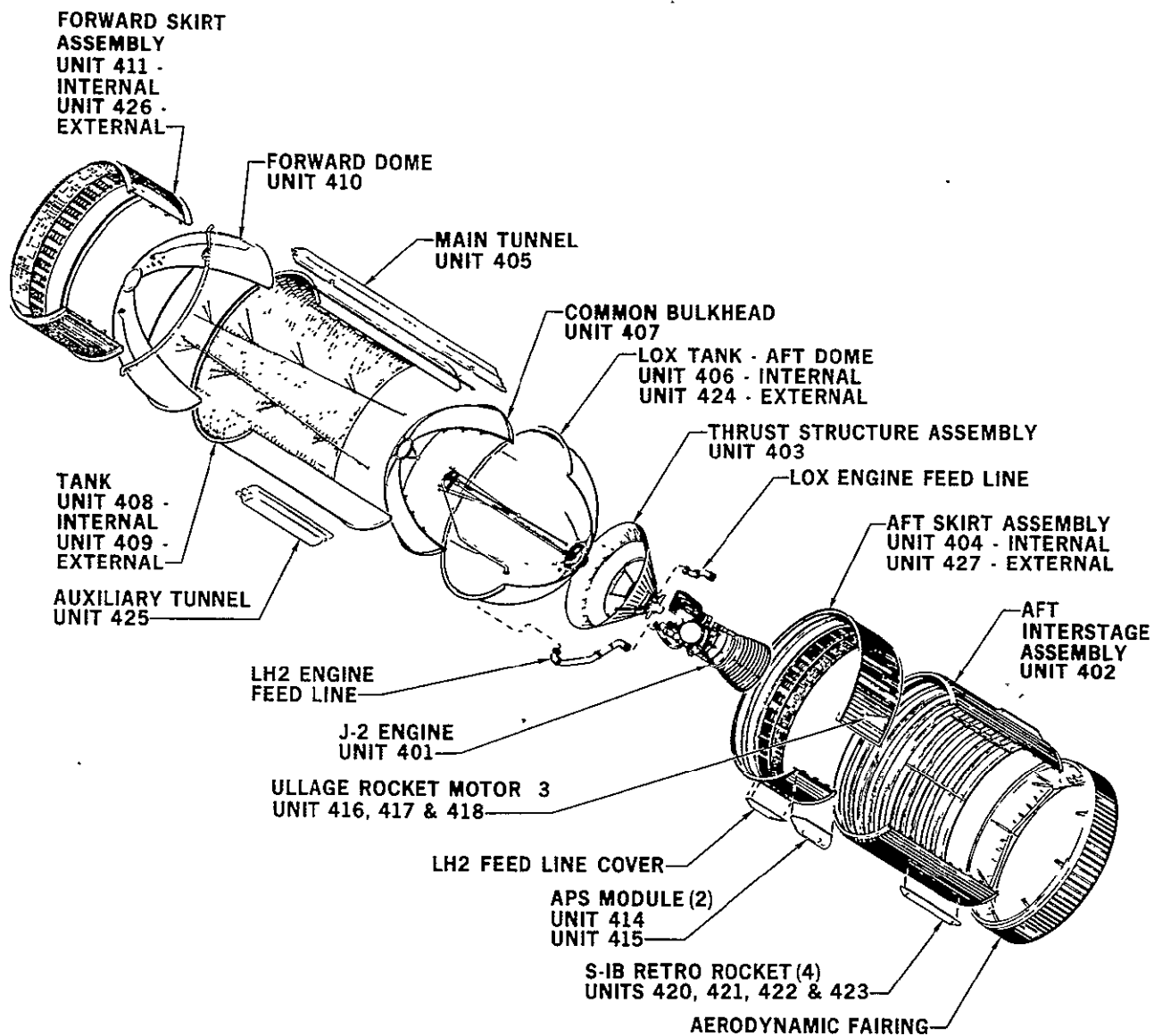
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Exploded View of S-IVB Stage for Saturn IB .

NARRATIVE END ITEM REPORT SATURN S-IVB-209

AUGUST 1968

DOUGLAS REPORT DAC-56502



PREPARED BY: W. M. REITZELL
BRANCH CHIEF, QUALITY DATA AND REPORTING
RELIABILITY ASSURANCE DEPARTMENT

PREPARED FOR:
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SPACE ADMINISTRATION
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APPROVED BY: K. A. FREDERIKSEN
CHIEF QUALITY ENGINEER
RELIABILITY ASSURANCE DEPARTMENT



APPROVED BY: W. W. REASER
DIRECTOR, SATURN PROGRAM
PRODUCT ASSURANCE

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

WESTERN DIVISION

MCDONNELL DOUGLAS



ABSTRACT

The Narrative End Item Report (NEIR) contained herein is a narrative summary of the Douglas Sacramento Test Center test records relative to the Saturn S-IVB-209 Flight Stage (Douglas, P/N 1A74633-515, S/N 2009).

Narrations are included on those conditions related to permanent nonconformances which were generated during the manufacturing cycle and existed at the time of Sacramento Test Center acceptance testing. The report sets forth data pertinent to total time or cycle accumulation on time or cycle significant items. Data relative to variations in flight critical components is also included. There is no provision to update or revise the NEIR after initial release.

Descriptors

NEIR

Documentation

Configuration

Significant Items

Stage Checkout

Prefire and Poststorage

PREFACE

This Narrative End Item Report is prepared by the Reliability Assurance Directorate of the McDonnell Douglas Astronautics Company, (MDAC), Western Division, for the National Aeronautics and Space Administration under Contract NAS7-101. This report is presented in response to requirements of NPC 200-2, Paragraph 14.2.4, and is issued in accordance with MSFC-DRL-021, Contract Data Requirements, which details the contract data required from MDAC. The report summarizes the period from initial stage acceptance testing at the MDAC Sacramento Test Center, Rancho Cordova, California, through turnover to the MDAC Florida Test Center, Cape Kennedy, Florida.

The previous period of stage acceptance testing at the MDAC Space Systems Center, Huntington Beach, California, and transfer to the MDAC Sacramento Test Center, was covered by Narrative End Item Report, Saturn S-IVB-209, Douglas Report DAC-56501, dated March 1967.

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SECTION 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Scope

The NEIR compiles quality evidence and assessments of a particular end item for use in evaluating program objectives and end item usage. This report narrates upon the Saturn S-IVB Stage, and discusses the following:

- a. Configuration at turnover for shipment to the Florida Test Center, Cape Kennedy, Florida.
- b. Replacements made during Sacramento Test Center (STC) test and acceptance checkout, including serial number of articles removed or substituted.
- c. Nature of problems and malfunctions encountered.
- d. Corrective action taken or pending.
- e. Extent of retests or tests not completed.
- f. Total operating hours or cycles for each time or cycle significant item.

1.2 Format

This document is organized into sections, with each section fulfilling a specific purpose. The title of each section and a brief outline of its purpose follow:

SECTION:

1. INTRODUCTION. This section discusses the scope of the NEIR, the Stage Design Concept, and Documentation.
2. NARRATIVE SUMMARY. A brief discussion of the principle test areas is presented to give management personnel a concise view of successful test achievement, and remaining areas of concern.
3. STAGE CONFIGURATION. Conformance to engineering design.
4. NARRATIVE. A presentation of checkout operations presented in the chronological order of testing. Failure and Rejection Reports (FARR's) are referenced as applicable for each paragraph.
5. POSTRETENTION. A presentation of stage configuration, additional stage testing prior to shipment (if any), final inspection, weight and balance, preshipment purge, retest requirements, post-checkout FARR's and flight critical items installed at shipment.

APPENDICES:

- I. TESTING SEQUENCE. Graphic presentation of the order and activity dates of the checkout procedures.

1.2 (Continued)

II. NONCONFORMANCE TABLES.

- a. TABLE I. A compilation of FARR's open at shipment from SSC.
- b. TABLE II. A compilation of FARR's initiated during prefire checkout.
- c. TABLE III. A compilation of FARR's initiated during countdown and postfire checkout.

1.3 Stage Functional Description

A detailed system analysis is beyond the scope of this report. The "S-IVB-IB Stage End Item Test Plan", 1B66532, contains a description of each operational system, and includes a listing of test procedures, with the objective and prerequisite of each test. The stage is primarily a booster stage consisting of propellant tanks, feed lines, electrical and pneumatic power for operation of stage systems, and such systems as are required for checkout purposes, fuel loading and unloading control, in-flight control and pressurization, and data measurement during these operations.

1.4 Documentation

Manufacturing and test records for this stage include Fabrication Orders (FO's), Assembly Outlines (AO's), Inspection Item Sheets (IIS's), Failure and Rejection Reports (FARR's), Serial Engineering Orders (SEO's), Radiographic Inspection Records, Hydrostatic test data, Vehicle Checkout Laboratory (VCL) test data, and vendor data. FO's and AO's record in sequence all manufacturing processes, procedures, and Quality Control inspection activities. Any problem or discrepancy noted by Inspection and Test personnel is recorded on an IIS for corrective action. Any discrepancy from a drawing requirement is recorded on a FARR by Inspection and Test personnel. The FARR is also used to record the Material Review Board (MRB) disposition applicable to the discrepancy. SEO's may be written to define the rework required by a FARR; to change the effectivity of a drawing; or to change other drawing requirements. Radiographic Inspection Records and X-ray photographs of all weld seams are maintained on file by the contractor. All original data is retained in the contractor's Reliability Assurance Department Central Data Files. Vendor technical data is received on functional purchased parts and also retained in Central Data Files. The majority of the documentation referenced within this report is included in the log book which accompanies the stage.

SECTION 2

NARRATIVE SUMMARY

2.0 NARRATIVE SUMMARY

The following paragraphs present a narrative summary of the systems checked out on the stage. Stage prefire and postfire checkouts conducted at the Sacramento Test Center (STC) are summarized in paragraphs 2.1 and 2.2, respectively. More detailed narrations on these tests and operations are presented in section 4.

Paragraph 2.3 comments on the preparations for stage retention at Sacramento.

2.1 Stage Prefire Acceptance Tests

The S-IVB stage acceptance test program, conducted at the Sacramento Test Center (STC), verified the functional capabilities of the stage systems, at sea level conditions, during static acceptance firing. The stage acceptance firing plan, SM-47459, delineated the general philosophies of the STC test programs. Test request 1046 authorized the acceptance firing and delineated the test objectives and requirements. The stage prefire checkouts were designed to ensure a condition of readiness for the stage, facility, and GSE to conduct a successful static acceptance firing program. A detailed narrative of the acceptance firing is delineated in Douglas Report SM-37550, dated July, 1967.

The stage was received at the STC on 10 March 1967. The prefire checkouts began at the VCL on 10 March 1967, and were concluded there on 9 May 1967, at which time the stage was removed in preparation for transfer to Test Stand Beta I for final prefire checkouts.

Thirteen procedures were performed in the VCL prefire checkout of the stage, commencing with prefire structural inspection. Two FARR's, A218924 and A251540, were generated during this inspection, and eleven revisions were recorded in the procedure. Prefire propulsion system leak and functional checks were successfully completed with four FARR's, A245479, A245481, A245484, and A245487, initiated, and twenty-four revisions written in the procedure.

2.1 (Continued)

Prior to installation of umbilical connections, a satisfactory electrical interface compatibility check was conducted without any problems or revisions to the procedure. Next, the stage power setup procedure was successfully demonstrated prior to applying power to the stage for other prefire checkouts. Three revisions were recorded in the stage power setup procedure.

The forward skirt thermoconditioning system checkout, the manual controls check for the stage valves, and verification of the cryogenic temperature sensors were completed satisfactorily without significant problems or FARR documentation. However, four revisions were recorded in the forward skirt thermoconditioning procedure and three revisions were recorded in the manual controls checkout.

The level sensor and control unit calibration procedure was completed without revisions. However, FARR A245524 was initiated against three faulty control units which were removed and replaced to permit satisfactory calibration.

The hydraulic system servicing procedure was conducted following replacement of the engine driven hydraulic pump and rework of the auxiliary hydraulic pump. A second issue of this procedure was necessary after installation of a hydraulic temperature probe. There were no significant problems or FARR documentation, but four revisions were recorded in issue 1 and three in issue 2. The hydraulic system setup, operation, and securing procedure was then run to prepare the system for the automatic test. A second issue was necessary following the automatic system test to shutdown and secure the hydraulic system in preparation for transfer of the stage from the VCL to Test Stand Beta I. There were no FARR's initiated for either issue of the procedure, but five revisions were written in issue 1 and one revision in issue 2. The automatic hydraulic system checkout was successfully completed without significant problems or FARR initiation. Three revisions were recorded in this procedure.

Automatic calibration of the digital data acquisition system was then satisfactorily accomplished without problems. No FARR documentation was necessary. Eight revisions were written into the procedure.

2.1 (Continued)

Demonstration of the stage power turnoff procedure completed the VCL prefire checkout operations. There were no problems, FARR's, or revisions recorded.

The stage was installed in Test Stand Beta I on 14 May 1967, for final prefire checkout. Nineteen prefire procedures involving stage hardware checkout were conducted. The umbilical interface compatibility test was accomplished prior to connecting umbilicals with no discrepancies recorded by FARR. Four revisions were written in the procedure. Demonstration of stage power setup was accomplished with one problem documented on FARR A251516, concerning low forward 5 volt excitation module voltage measurements caused by ground return line loss. Three revisions were recorded in the procedure. Stage power turnoff was then demonstrated without FARR documentation or procedure revision. Power distribution system checks were successfully conducted without generating any FARR's. There were seventeen revisions written against the procedure.

The forward skirt thermoconditioning system was checked to prepare it for operation on the test stand, the manual controls check for the stage valves was accomplished satisfactorily, calibration of cryogenic temperature sensors was verified, and the hydraulic system setup and operation procedure was conducted to prepare the system for automatic testing. These checkouts were conducted without significant problems resulting in FARR documentation. However, a total of sixteen revisions were recorded against the four procedures. Four revisions were recorded for the forward skirt thermoconditioning procedure, two in the manual controls procedures, one for the cryogenic temperature sensor verification, and nine in the hydraulic system setup procedure.

Propulsion system leak checks resulted in one area of unacceptable leakage documented by FARR A251541. This leakage was corrected by replacement of the LOX tank pressurization control module. Twenty-eight revisions were written against the procedure.

The telemetry and range safety antenna system procedure was used to test the PCM RF assembly following rework. There were no problem areas encountered and the one revision written deleted all portions of the procedure except the PCM RF test.

2.1 (Continued)

The level sensor and control unit calibration procedure was conducted on the test stand without FARR documentation. One revision was written to authorize a second issue of the procedure to checkout the LOX point level 4 sensor and control unit calibration because the adjustment seal was discovered missing a few weeks after completion of the initial issue.

The propellant tank common bulkhead vacuum checkout was conducted, verifying that the bulkhead was free from leakage and acceptable for propellant loading. One FARR, A251439, was initiated against the bulkhead top fitting when inspection revealed the fitting to be plugged with sealant. The restriction was removed by cleaning. Seven revisions were recorded in the procedure.

The propellant utilization (PU) system calibration procedure was conducted with two revisions recorded, including one which reran the portion of the procedure required to checkout the static inverter-converter. This unit had been replaced after failure during the initial test per FARR A251546. There were no other discrepancies. Automatic testing of the PU system was accomplished satisfactorily without FARR documentation. Two revisions were recorded in the procedure.

The propulsion system automatic test was successfully accomplished after nineteen revisions were recorded in the procedure. No FARR's were written as a result of this test.

The signal conditioning setup procedure was run to check the adjustment of the forward 5 volt excitation module voltages. These voltages had been measured below the allowable tolerance during stage power setup as noted previously. Adjustment was determined to be satisfactory and no FARR's were initiated. One revision was written to delete all portions of the procedure, except those concerning the checkout of the forward 5 volt excitation modules.

The digital data acquisition system automatic test was successfully accomplished after processing fourteen revisions in the procedure. There were no significant problems resulting in FARR documentation. The integrated system test was performed satisfactorily without FARR initiation. Twenty-three revisions were recorded in the procedure.

2.1 (Continued)

Prefire checks of the stage were concluded by running the final leak check procedure. No unacceptable leakage was detected and no FARR's were initiated. Twenty-six revisions were required to satisfactorily complete this procedure.

The simulated static firing was initiated on 8 June 1967, and successfully completed on 9 June 1967.

Two runs were required to accomplish the stage acceptance firing per Test Request 1046. Run 1A was initiated on 13 June 1967, and was terminated on 14 June 1967, when engine ignition was not obtained as a result of a signal complement error causing the computer to stop the automatic operation. Run 2A was started on 19 June 1967; and the firing was terminated on 20 June 1967, with a successful firing of 456 seconds of mainstage operation.

2.2 Stage Postfire Checkout

Contract Change Order 1312 delineated a short series of post acceptance firing checkouts to be accomplished prior to the extended storage of the stage at STC. The following is a bried recap of the abbreviated prestorage postfire checkouts accomplished per Test Request 1046, addendum I, on Test Stand Beta I.

Postfire checkout following completion of acceptance firing was initiated on 26 June 1967, with the successful demonstration of the stage power setup and turnoff procedures. There were no discrepancies recorded by FARR's for either procedure. Two revisions were recorded in the procedure for stage power setup and one recorded for stage power turnoff.

The propulsion system leak check was conducted from 26 through 30 June 1967, to determine leakage that could have resulted from the stage acceptance firing. No unacceptable leakages were detected, and no FARR's were initiated. Thirty-two revisions were required to satisfactorily complete the procedure.

The integrated systems test (IST) procedure was conducted on 28 June 1967, for a data evaluation comparison with the prefire IST, as required by Contract Change Order 1312. There were no FARR's generated as a result of the postfire IST; however, thirty-three revisions were required to complete the procedure.

2.2 (Continued)

The postfire operation and securing procedure for the hydraulics system was conducted on 29 and 30 June 1967, to secure the system and prepare it for shipment to the VCL for extended storage. There were no problem areas resulting in FARR documentation.

The final prestorage postfire procedure conducted was the forward skirt thermoconditioning system checkout. This prepared the thermoconditioning system for shipment to the VCL for storage preparation. No FARR's were initiated, but four revisions were recorded in the procedure.

The stage was removed from the test stand on 6 July 1967, and transferred to the VCL for storage preparations on 7 July 1967.

2.3 Stage Retention

Contract Change Order 1312 and WRO A45-S-IVB-292 authorized retention of the stage in storage at STC after completion of the abbreviated prestorage postfire checkout. The stage was prepared for extended storage per H&CO 1B67536, Stage Storage Procedure, at the VCL and was placed in storage on 19 July 1967, in the E&D building at STC. Those activities occurring during stage storage and during the subsequent preparations for stage shipment to FTC are covered in section 5.

SECTION 3

STAGE CONFIGURATION

3.0 STAGE CONFIGURATION

Paragraph 3.1 discusses the means used to verify the stage configuration. Stage variations which represent changes in the scope of the program are presented in section five. A listing of all time/cycle significant items on the stage, along with the accumulated time/cycles for each, is presented in paragraph 3.2A.

3.1 Design Intent Verification

This configuration of the stage is defined in the Engineering Configuration List (ECL), Space Vehicle, Model DSV-4B-2-1, Manufacturing Serial Number 2009, revision C, dated 21 August 1967. This ECL document includes a listing of all parts, non-hardware drawings, and manufacturing and process specifications required for the manufacture and test of the stage, as defined by Engineering production drawings and Engineering Order (EO) releases. The ECL has been transmitted to NASA under a separate cover.

Verification of design intent was accomplished by comparing the ECL with the Planning Configuration List (PCL), and the Reliability Assurance Department As-Built Configuration List (ABCL). Any discrepancies found were resolved by the contractor, and a listing of the resultant action is filed at the contractor's facility.

3.2 Time/Cycle Significant Items

Twenty-six items installed on the stage at the time of storage at STC are time/cycle significant as defined by design requirements drawings 1B55423, Government Furnished Property Time/Cycle Significant Items, and 1B55425, Reliability Time/Cycle Significant Items. The following table lists these items, along with the time/cycle accrued on each item, and the maximum allowable limits prescribed by Engineering. Three additional time/cycle significant items, a command receiver, P/N 50M10697, and two PU bridge potentiometers, P/N 1A59562, were not installed at the time of storage.

<u>Part Number and Part Name</u>	<u>Serial Number</u>	<u>Accumulated Measurement</u>	<u>Engineering Limit</u>
Reliability Items (1B55425 P)			
<u>1A48858-1</u>	1092	7 cycles	50 cycles
Helium Storage Sphere	1101	7 cycles	50 cycles
	1110	7 cycles	50 cycles
	1150	7 cycles	50 cycles
	1155	7 cycles	50 cycles
	1159	7 cycles	50 cycles

3.2 (Continued)

<u>Part Number and Part Name</u>	<u>Serial Number</u>	<u>Accumulated Measurement</u>	<u>Engineering Limit</u>
<u>1A49421-505</u> LH ₂ Chillo down Pump	188	(Data Not Available)	100 hours
<u>1A49423-507</u> LOX Chillo down Pump	1761	145.32 minutes	1,200 minutes
<u>1A66241-509</u> Auxiliary Hydraulic Pump	X454673	23.1 hours 93 cycles	120 hours 300 cycles
<u>1B57731-1</u> Control Relay Package	343 348	280 cycles 272 cycles	100,000 cycles 100,000 cycles
G.F.P.Items (1B55423 G)			
<u>40M39515-113</u> EBW Firing Unit	230 231	37 firings 33 firings	1,000 firings 1,000 firings
<u>40M39515-119</u> EBW Firing Unit	399 409 410 411 412 413 417 430	21 firings 31 firings 34 firings 34 firings 33 firings 34 firings 34 firings 22 firings	1,000 firings 1,000 firings 1,000 firings 1,000 firings 1,000 firings 1,000 firings 1,000 firings 1,000 firings
<u>50M10697</u> Command Receiver	117	27.9 hours	2,000 hours
<u>50M10698</u> Range Safety Decoder	128 131	30.8 hours 30.1 hours	2,000 hours 2,000 hours
<u>50M67864-5</u> Switch Selector	156	(Data Not Available)	250,000 cycles
<u>103826</u> J-2 Engine (for gimbal cycles)*	J-2083		
a. Customer connect lines and inlet ducts		20.31%	250-10,000 cycles
b. Gimbal bearings		16.27%	250-10,000 cycles
c. Firing time		887.753 sec	3,750 seconds
d. Helium Regulator		(Data Not Available)	Not Established

*This data includes all engine gimbal cycles at STC, plus cycles brought forward from Rocketdyne records. The cycle data is expressed as a percent of design limits based on the gimbal angle, and can vary from 250 to 10,000 + cycles as noted. The indicated percentages were computed from the Engine Log Records utilizing the graph per Rocketdyne Rocket Engine Data Manual R-3825-1.

SECTION 4

NARRATIVE

4.0 NARRATIVE

The paragraphs of this section narrate upon the stage checkout in the chronological order of testing. The major paragraphs comprising the narrative are: 4.1 Prefire Stage Checkout, and 4.2 Postfire Stage Checkout. Each major paragraph is subdivided to the degree required to present a complete historical record of stage checkout.

Nonconformances and functional failures affecting the stage are recorded on FARR's, and are referred to by serial number throughout this section (e.g. FARR A251540). The referenced FARR's are presented numerically by serial number in Appendix II.

4.1 Prefire Stage Checkout

Thirty-two prefire procedures were conducted on the stage at STC to prepare and qualify it for the static acceptance firing. The first thirteen procedures were accomplished in the VCL and are reported in detail in paragraphs 4.1.1 through 4.1.13. Paragraphs 4.1.14 through 4.1.32 describe the nineteen prefire checkouts conducted after transfer of the stage from the VCL to Test Stand Beta I.

4.1.1 Prefire Structural Inspection (1B40645 B)

Performed between 10 March 1967 and 22 May 1967, this inspection verified that transportation of the stage from SSC to STC had no detrimental effect on the structure; and also established the condition of the stage prior to static acceptance firing, for comparison with the stage condition subsequent to a full duration static firing program.

Prior to rotating or moving the stage from the horizontal position in which it was shipped, the area between the forward skirt and the forward dome was visually inspected and determined to be free of debris.

After completion of stage installation into the test stand, the forward access kit and the protective cover kit were installed.

4.1.1 (Continued)

An external visual inspection was performed on the LOX and LH₂ tank assembly, P/N 1A39303-525, the thrust structure, P/N 1A39312-511, the forward skirt assembly, P/N 1B29824-509, the main tunnel installation, P/N 1B39313-503, the auxiliary tunnel installation, P/N 1B27716-1, and the propulsion system installation, P/N 1A39318-531, with emphasis on the following mandatory items:

- a. Cracked or debonded clips and brackets.
- b. Dents or scratches in the low pressure ducts.
- c. Scratches or finish discrepancies on the spheres.
- d. Leakage or spillage in the hydraulic system.
- e. Loose or uncapped tubing, or missing clamps.
- f. Loose or uncapped electrical connectors.
- g. Loose hardware or foreign material.
- h. Cracks or deformation in skin panels or stringers.
- i. Chipped, peeled, or damaged paint.
- j. Damaged or debonded external insulation.
- k. Cracked stringer caps.
- l. Repetitive nonconformance list (RNL) items.

A radiographic inspection of the V-section between the forward skirt and the forward dome (from station 554.702 to station 566.702), the aft dome/thrust structure V-section, and the aft dome/aft skirt V-section, was made for debris or foreign material. There were seven discrepancies noted during this section, two of which were recapped to FARR A251540:

- a. Three inclusions, possibly aluminum chips, were located in the V-section of the aft dome/thrust structure and measured 0.125 by 0.1 in., 0.175 by 0.050 in., and 0.150 by 0.50 in., respectively.
- b. A paper clip was discovered on an X-ray of the aft skirt, between stringers 45 and 46, and was triangulated to be located in the bulkhead honeycomb. A tangential X-ray further substantiated that the clip was pressed lengthwise into the honeycomb from the aft side.

Both of these conditions were accepted by material review action.

4.1.1 (Continued)

An LH₂ tank internal inspection was required due to entry into the LH₂ tank to perform AO modifications on the LH₂ mass probe lower mount. A visual inspection of the main fuel tank components for cracks, deformation, looseness, and corrosion was performed and delineated as follows:

- a. The cold helium bottles, straps, fittings, and couplings, with emphasis on the bottles for dents, pits, scratches, and corrosion.
- b. The fuel sensor probe installation support, P/N 1A57675.
- c. The LH₂ mass sensing probe, P/N 1A49551-501, and attachments.
- d. The LH₂ transducer support installation, P/N 1A77907.
- e. The LH₂ wiring instrumentation feedthrough, P/N 1A49544.
- f. The fuel tank vent system and attachments.
- g. The fuel anti-vortex screen, P/N 1A48633, and top, P/N 1B55464, for cracks.
- h. The insulation installation, P/N 1A39314-519.
- i. The forward dome of the common bulkhead, P/N 1A39309.

There were no discrepancies noted during the internal inspection of the LH₂ tank.

Internal inspection of the LOX tank was not accomplished since entry was not required.

Two FARR's were written during the operation of this procedure and are described as follows:

- a. FARR A218924 listed those discrepancies which were discovered during the receiving portion of the structural inspection per IIS 335859. These discrepancies were of a temporary nonconformance type and were listed for corrective action requirements only.
- b. FARR A251540 listed the radiographic inspection discrepancies noted during that portion of the procedure.

There were eleven revisions written against this test procedure, and those incorporated were:

- a. One revision added instructions for the inspection of the common bulkhead fittings, P/N's 1B29958-1 and 1B29959-1, for plugging or restrictions.

4.1.1 (Continued)

- b. One revision deleted the use of the vertical access kit, since inspection was performed in the horizontal position, and deleted the torque requirements of the cold helium bottle coupling bolts, as they were previously checked at SSC.
- c. One revision corrected procedural requirements that were in error.
- d. One revision removed the sphere, P/N 1B55725-1, to determine the serial number.
- e. One revision added steps to perform a leak and decay check of the air bottle assembly installation, P/N 1B55408-503, to verify system integrity.
- f. One revision was required for additional radiographic inspection of the aft dome/thrust structure V-section and the aft dome/aft skirt V-section, to verify that there was no debris or foreign material in these areas.
- g. One revision performed additional radiographic inspections to determine the location of a paper clip located in the aft area of the stage, and was accomplished in conjunction with FARR A251540.
- h. One revision deleted the APS module fit check section since it would be accomplished during postfire checkout at the VCL.
- i. One revision performed additional sphere inspections prior to firing at day T-7.
- j. One revision deleted the LOX tank entry section since entry was not required.
- k. One revision deleted the installation of the thrust structure doors since this item is performed during Task 16 of countdown 1B70271.

The prefire structural inspection was accepted by Engineering, and this test procedure was signed off on 7 June 1967.

4.1.2 Umbilical Interface Compatibility Check (1B59768 C)

Prior to connecting the forward and aft umbilical cables for automatic power on checks at the STC VCL, this manual checkout provided the test sequences with which to check the design specifications and continuity of the stage umbilical wiring. Accomplished by point-to-point resistance checks of all umbilical circuits, this test assured that proper loads were present on all power busses and that the control circuits for propulsion valves and safety items on the stage were within prescribed tolerances.

4.1.2 (Continued)

This procedure was initiated and completed at VCL on 4 April 1967. A series of resistance measurements were made at specified test points on the GSE signal distribution unit, P/N 1A59949-1, Model 463, using test point/terminal 463A1A5-J43FF as the common point for all measurements. These measurements verified that all wires and connections in the umbilical cables and stage umbilical wiring were intact and of the proper material and wire gauge, and that all resistance values and loads were within the design requirement limits. A Simpson Model 260 multimeter was used to make the resistance measurements. See Test Data Table 4.1.2.1 for particular test points, circuit functions, measured resistances, and resistance limits.

There were no problems during the test, no FARR tags were initiated, and no revisions were recorded in the procedure.

4.1.2.1 Test Data Table, Umbilical Interface Compatibility Check

Reference Designation - 463A2

<u>Test Point</u>	<u>Function</u>	<u>Meas.</u> <u>Ohms</u>	<u>Limit</u> <u>Ohms</u>
A2J29-C	Cmd., Ambient Helium Sphere Dump	27	10-60
CB-8-2	Cmd., Engine Ignition Bus Power Off	Inf.	Inf.
CB-9-2	Cmd., Engine Ignition Bus Power On	7.5	5-15
CB-10-2	Cmd., Engine Control Bus Power Off	Inf.	Inf.
CB-11-2	Cmd., Engine Control Bus Power On	10	5-15
A2J29-N	Cmd., Engine He Emerg Vent Control On	50	10-60
A2J29-Y	Cmd., Start Tk Vent Pilot Valve Open	23	10-60
CB-4-2	Cmd., LOX Tank Cold He Sphere Dump	32	10-60
A2J29-h	Cmd., Fuel Tank Vent Pilot Vlv Open	50	50 max
	(Same, reverse polarity)	Inf.	500K min
A2J29-i	Cmd., Fuel Tank Vent Vlv Boost Close	50	50 max
	(Same, reverse polarity)	Inf.	500K min
A2J29-q	Cmd., Ambient He Supply Shutoff Vlv Close	28	10-60
A2J30-H	Cmd., Cold He Supply Shutoff Vlv Close	1.3K	1.5K max
	(Same, reverse polarity)	Inf.	Inf.
A2J30-W	Cmd., LOX Vent Valve Open	50	10-60
A2J30-X	Cmd., LOX Vent Valve Close	50	10-60
A2J30-Y	Cmd., LOX & Fuel Emerg Close	49	100 max
	(Same, reverse polarity)	Inf.	Inf.
A2J30-Z	Cmd., LOX & Fuel Chillover Vlv Close	50	10-60
A2J30-b	Cmd., LOX Fill & Drain Vlv Boost Close	23	10-30
A2J30-c	Cmd., LOX Fill & Drain Vlv Open	22	10-30

4.1.2.1 (Continued)

<u>Test Point</u>	<u>Function</u>	<u>Meas.</u> <u>Ohms</u>	<u>Limit</u> <u>Ohms</u>
A2J30-d	Cmd., Fuel Fill & Drain Vlv Boost Close	22	10-30
A2J30-e	Cmd., Fuel Fill & Drain Valve Open	22	10-30
A2J42-F	Meas., Bus +4D111 Regulation	130	100-200
A2J35-y	Meas., Bus +4D141 Regulation	280	50-600
A2J6-AA	Sup., 28v Bus +4D119 Talkback Power	85	60-100

Reference Designation 463A1

A5J41-A	Meas., Bus +4D131 Regulation	1400	900-1400
A5J41-E	Meas., Bus +4D121 Regulation	2.1K	1.6K min
A5J53-AA	Sup., 28v +4D119 Fwd Talkback Power	70	60-100

4.1.3 Prefire Propulsion System Leak and Functional Checks (1B70773 N/C)

This checkout procedure defined the operations required to perform the leak and functional checks which certified the stage propulsion system prior to static firing. The prefire test sequences performed during this checkout, initiated on 4 April 1967, and completed on 16 May 1967, consisted of the following system checkout.

The cold helium fill module relief test and internal seat leakage test was accomplished by removal of the module from the stage for shipment to LOX service for leakage and relief tests per 1B57781. Both checks were satisfactorily completed and the data appears within Test Data Table 4.1.3.1.

The LOX chilldown pump purge and engine pump purge pressure switch checks performed a pickup and dropout test of the switches by cycling them three times through their pressure range. The LOX pump purge module, P/N 1A58347-505, S/N 059, was cycled and checked for control and dump valve seat leakage. All checks were satisfactorily complied with. Stage pneumatics system leak and functional checks performed:

- a. Ambient helium fill module internal leakage and backup check valve reverse leakage.

4.1.3 (Continued)

- b. Control helium system leak checks and actuation control module internal leakage was accomplished by checking for leakage at the vent ports of the LOX and LH₂ fill and drain valve actuation control modules, the LOX and LH₂ vent valve actuation control modules, the pre valve chilldown actuation control module, the chilldown valves actuation control module, and the directional vent valve actuation control module.
- c. Purge system check valve reverse leakage was accomplished by monitoring the reverse flow of the LOX and LH₂ fill and drain purge check valve, the nonpropulsion vent purge check valve and the LOX vent purge check valve.

The stage pneumatics system leak and functional checks were satisfactorily completed and data appears within the Test Data Table. The engine start system leak and functional checks performed leakage checks of the start tank dump control solenoid seal, vent and relief valve, and valve bellows. All tests of the engine start system were satisfactorily completed.

Engine check valve reverse leakage checks performed a forward flow and reverse leakage test of the LH₂ pump drain and pump purge check valve, the LH₂ turbine seal cavity purge check valve, the LOX turbine seal cavity check valve, and a leakage test of the LH₂ pump intermediate seal. The engine check valve reverse leakage checks were satisfactorily completed.

Engine gas generator (GG) and exhaust system leak checks performed engine seal leakage checks, which included a reverse leakage test of the GG fuel purge check valve and seal leakage tests of the LH₂ turbine seal, the LOX turbine seal, and the start tank discharge valve gate seal. Gas generator exhaust system leak checks included a leakage test of the oxidizer carrier flange and reverse leakage tests of the gas generator LOX poppet and purge check valve. A leakage check of the hydraulic pump shaft seal was also performed during this section with satisfactory results. There was one leakage condition noted during this section. The start tank discharge valve gate seal reverse leakage was measured as 765 scim, exceeding the 20 scim maximum limit. This was corrected by cleaning the sealing surfaces with freon. The hot gas system was pressurized and the STDV gate seal was rechecked with satisfactory results. All other sections of the engine GG and exhaust system leak checks were satisfactorily completed.

4.1.3 (Continued)

Engine pump purge leak and flow checks performed a regulation check of the engine pump purge module discharge pressure, measured the seat leakage of the engine pump purge valve, and checked the purge flows of the LOX and LH₂ turbine seal cavity bleed exits, the LH₂ pump drain test port, and the GG fuel purge flow of the LH₂ turbo pump access. All engine pump purge leak and flow checks were satisfactorily completed.

The LH₂ tank pressurization system leak checks performed a reverse leakage test of the fuel pressure module check valve and LH₂ pressurization redundant check valve. Both of these checks failed on initial tries and were corrected by replacement of the gasket, P/N 51134-150-A1, on the former, while the latter was corrected by replacement of check valve, P/N 1B53920-501, S/N 051, with P/N 1B53920-501, S/N 040. This section also tested the reverse leakage of the LH₂ prepressurization check valve and was satisfactorily completed.

Thrust chamber leak checks performed reverse leakage tests of the LOX dome purge check valve and the thrust chamber purge check valve, and seal leakage checks of the main fuel valve and the main oxidizer valve idler and drive shaft seals. One leakage condition was noted at the thrust chamber turnaround manifold drain screw adjacent to tube 360, which was corrected by subsequent seal replacement. All tests were satisfactorily completed.

Engine pneumatics leak and functional checks performed:

a. Engine solenoid energized leak checks which included:

1. Leak checks of the circuits from the normally open ports of the ignition phase and mainstage solenoids, the pressure actuated fast shutdown valves diaphragm, and the internal pneumatic components.
2. Leak check of the ignition phase solenoid normally closed circuit, STDV solenoid seat leakage (closed position), STDV piston seal leakage (closed position), and internal pneumatic components leakage check.
3. Seat leakage check on the STDV solenoid and piston seal (open position); also a leak check of the STDV solenoid circuit.

4.1.3 (Continued)

4. Leak check of the pressure actuated fast shutdown valve seat and internal pneumatic components.
- b. Engine control bottle fill system reverse leakage of the engine control bottle fill check valve.
- c. Pressure actuated purge system leak check included a seat leakage test of the purge valve vent.
- d. Engine control bottle fill system reverse leakage test of the check valve.

There were two leakage conditions noted during this section. One leak was noted on the R/NAA publication RAD-206-192, revision "A". The other leak was detected at the pressure actuated purge valve inlet line attach flange, P/N 554793-15, and was corrected by replacement of an incorrect seal, P/N 404673-3, with the correct seal, P/N 404666-7. All tests of the engine pneumatics system were satisfactorily completed.

The LOX tank pressurization system leak and functional checks performed a reverse leakage test of the cold helium fill check valves and the LOX pre-pressurization check valve, and an internal leakage and functional test of the LOX pressure module, including a seat leakage check of the cold helium shutoff valve and hot gas valve. Two leaks were observed during the LOX pressurization system leak check. One at the LOX pressurization control module, P/N 1B42290-503, S/N 0025, was corrected by retightening to the proper torque value, and one at the union between pipe assemblies, P/N's 1B64135-1 and 1B64131-1, was corrected by replacement of the pipe assembly, P/N 1B64131-1, and the union, P/N MC160-C16. This section was satisfactorily completed.

A pressure check of the J-2 engine electrical control assembly and the auxiliary and primary instrumentation packages was satisfactorily completed.

Ten leakage conditions were described in the leak check log. Seven were corrected by retightening to the proper torque value, or by replacement of seals or components with subsequent tightening to the proper torque value. Three leakage conditions were noted during R/NAA system leak checks, of which one was associated with the start tank discharge valve gate seal. This leakage condition was corrected by cleaning the sealing surfaces with freon

4.1.3 (Continued)

per instructions from R/NAA. The second R/NAA associated leakage condition was noted at the Schraeder valve on the auxiliary instrumentation package, and was corrected by replacement. The third leakage condition was subsequently found to be acceptable per R/NAA publication, as noted in the engine pneumatics leak and functional checks.

Four FARR's were written during the operation of this test procedure.

- a. FARR A245479 removed and replaced the pneumatic power control module, P/N 1B43657-509, S/N 016, with S/N 022. Reason for replacement: the module malfunctioned twice during checkout at the A3 VCL.
- b. FARR A245481 removed and replaced the LH₂ pressure redundant check valve, P/N 1B53920-501, S/N 015, with S/N 040. Reason for replacement: valve reverse leakage was excessive.
- c. FARR A245484 removed and replaced LOX tank pressurization system pipe assembly, P/N 1B64131-1. Reason for replacement: damaged flare.
- d. FARR A245487 removed and replaced the LH₂ V&R valve, P/N 1A48257-509, S/N 0043, with S/N 0047. Reason for replacement: improperly machined mount ear.

There were twenty-five revisions written against this test procedure, with one of these subsequently deleted. The revisions incorporated were:

- a. Seventeen revisions corrected or added requirements that were in error or missing.
- b. Three revisions provided steps necessary to determine, correct, and releak check the high pressure STDV gate seal which had developed an excessive reverse flow leakage condition during engine GG and exhaust system leak checks.
- c. One revision authorized a pressure check of the G2 spark cable.
- d. One revision authorized the use of a union, P/N AN-815-4C, and a cap, P/N AN-929, as a substitution for plug assembly, P/N 9651-59061, used during engine pneumatic leak checks. The plug assembly was not available during leak checks.
- e. One revision delineated steps for leak checking of the LH₂ pressure redundant check valve after replacement.
- f. One revision deleted sections of this procedure which were to be accomplished during H&CO 1B71877.

There were no missing or substitute parts, modifications, or EO's pending that would void any portion of this test. The propulsion systems leak and functional checks were accepted by Engineering and this test procedure was signed off on 18 May 1967.

4.1.3.1 Test Data Table, Prefire Propulsion System Leak and Functional Checks

Pressure Switch Checks

<u>Function</u>	<u>Run 1</u>	<u>Run 2</u>	<u>Run 3</u>	<u>Limits</u>
LOX Chillydown Pump Purge PS Pickup (psia)	52.5	52.5	52.5	54 max
LOX Chillydown Pump Purge PS Dropout (psia)	49.0	49.5	49.5	49 min
Engine Pump Purge PS Pickup (psia)	125.0	125.0	125.0	130 max
Engine Pump Purge PS Dropout (psia)	114.0	115.0	115.0	105 min

LOX Pump Purge Control Module Checks

(P/N 1A58347-505, S/N 059, Ref. Loc. 403A75A2)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Module Flow Rate (scim)	45.5	33 to 49
Control Valve Seat Leakage (scim)	0.0	1 max
Maximum Cycle Pressure (psig)	37.5	*
Minimum Cycle Pressure (psig)	34.6	*
Cycle Time (minutes)	2.5	*
Dump Valve Seat Leakage (scim)	0.0	0.0

Vacuum Checks

<u>Vacuum Jacketed Duct</u>	<u>Vacuum Pressure (microns of Hg.)</u>	
	<u>Measurement</u>	<u>Limits</u>
LH ₂ Upper Feed Duct	26.0	150.0 max
LH ₂ Lower Feed Duct	65.0	150.0 max
LH ₂ Recirculation Duct	13.0	150.0 max

Ambient Helium Fill Module Checks

(P/N 1A57350-507-002, S/N 0212)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Check Valve Reverse Leakage (scim)	0.0	0.0 max
Control He Bottle Dump Valve Seat Leakage (scim)	0.0	0.0 max
Fill Line Check Valve Reverse Leakage (scim)	0.0	10.0 max

Actuation Control Module Checks

(P/N 1A49982-517)

<u>Module Function</u>	<u>S/N</u>	<u>Ref. Loc.</u>	<u>Vent Port Leakage (scim)</u>			
			<u>Normal</u>	<u>Open</u>	<u>Boost</u>	<u>Limit</u>
LH ₂ Fill & Drain Valve Control	013	404A44	0.0	0.0	0.0	1.2 max
LOX Fill & Drain Valve Control	038	404A9	0.0	0.0	0.0	1.2 max
LH ₂ Vent Valve Control	008	411A2	0.0	0.0	0.0	1.2 max
LOX Vent Valve Control	035	403A75A1	0.0	0.0	0.0	1.2 max
Prevalve and Chillydown Valve Control	036	404A43	0.0	0.0	0.0	1.2 max
			<u>Normal</u>	<u>Flight</u>	<u>Ground</u>	
Directional Vent Valve Control	123	411A30	0.0	0.0	0.0	1.2 max

*Limits Not Specified

4.1.3.1 (Continued)

LH₂ Vent Boost Decay Check

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Control Sphere Initial Pressure (psig)	548.0	*
Control Sphere Final Pressure (psig)	529.0	*
Decay Check Duration (sec)	15.0	*

Purge System Check Valve Reverse Leakage Check

(P/N 1B51361-1)

		<u>Reverse Leakage (scim)</u>	
<u>Check Valve Function</u>	<u>S/N</u>	<u>Measurement</u>	<u>Limits</u>
LOX Fill & Drain Purge	223	0.0	10.0 max
LH ₂ Fill & Drain Purge	240	0.0	10.0 max
Nonpropulsive Vent Purge	241	0.0	10.0 max
LOX Vent Purge	255	0.0	10.0 max

Engine Start Tank Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Dump Control Solenoid Seat Leakage (scim)	0.0	10.0 max
Vent and Relief Valve Leakage (scim)	0.7	10.0 max
Dump Valve Bellows Leakage (scim)	0.0	0.0 max

Engine Check Valve Reverse Leakage Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
<u>LH₂ Pump</u>		
Drain Check Valve Reverse Leakage (scim)	0.0	25.0 max
Pump Check Valve Forward Flow at 30 psig (scim)	0.0	30.0 max
Pump Check Valve Forward Flow at 60 psig (scim)	5400.0	2420.0 min
Purge Check Valve Reverse Leakage (scim)	0.0	25.0 max
Intermediate Seal Leakage (scim)	12.2	500.0 max

LH₂ Turbine Seal Cavity

Purge Check Valve Reverse Leakage (scim)	0.0	25.0 max
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LOX Turbine Seal Cavity

Purge Check Valve Reverse Leakage (scim)	0.0	25.0 max
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*Limits Not Specified

4.1.3.1 (Continued)

Engine Gas Generator and Exhaust System Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
GG Fuel Purge Check Valve Reverse Leakage (scim)	0.0	25.0 max
LH ₂ Turbine Seal Bleed Leakage (scim)	1950.0	12000.0 max
LOX Turbine Seal Bleed Leakage (scim)	2.8	350.0 max
STDV Gate Seal Reverse Leakage (scim)	1.41	20.0 max
Hydraulic Pump Shaft Seal Leakage (scim)	5.3	228.0 max
Oxidizer Carrier Flange Leakage (scim)	0.62	20.0 max
GG LOX Poppet Reverse Leakage (scim)	265.0	600.0 max
GG LOX Purge Check Valve Reverse Leakage (scim)	0.0	15.0 max

Engine Pump Purge Control Module Checks

(P/N 1A58347-507, S/N 054, Ref. Loc. 403A73A2)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Purge Valve Seat Leakage (scim)	0.0	12.2 max
Discharge Pressure (psig)	82.0	67 to 100
GG Fuel Purge Flow (scim)	4250.0	2250.0 min
LOX Turbine Purge Flow (scim)	3500.0	2250.0 min
LH ₂ Turbine Purge Flow (scim)	2825.0	2250.0 min
Fuel Seal Cavity Flow (scim)	830.0	200.0 min

LH₂ Pressurization Control Module Checks

(P/N 1B66230-1, S/N 1036, Ref. Loc. 403A73A3)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Check Valve Reverse Leakage (scim)	0.0	10.0 max
Redundant Check Valve Reverse Leakage (scim)	8400.0**	6000.0 max

LH₂ Prepressurization Check Valve Check

(P/N 1B65673-1, S/N 20)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Reverse Leakage (scim)	0.0	0.0 max

Thrust Chamber Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
<u>LOX Dome</u>		
Purge Check Valve Reverse Leakage (scim)	0.0	0.0 max

**(Reference FARR A245481)

4.1.3.1 (Continued)

Thrust Chamber Checks (Continued)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
<u>Main Fuel Valve</u>		
Idler Shaft Seal Leakage (scim)	0.0	10.0 max
Drive Shaft Seal Leakage (scim)	0.0	10.0 max
<u>Main Oxidizer Valve</u>		
Idler Shaft Seal Leakage (scim)	0.0	10.0 max
Drive Shaft Seal Leakage (scim)	0.0	10.0 max
<u>Thrust Chamber</u>		
Pressure (psig)	30.0	20.0 min
Jacket Purge Check Valve Reverse Leakage (scim)	9.8	25.0 max

Engine Pneumatics Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Helium Control Solenoid Seat Leakage (scim)	4.7	20.0 max
Ignition Phase Solenoid Seat Leakage (scim)	1.8	20.0 max
Mainstage Solenoid Seat Leakage (scim)	5.25	20.0 max
<u>Start Tank Dump Valve 4-Way Solenoid</u>		
Seat Leakage, Valve Closed (scim)	12.0	15.0 max
Seat Leakage, Valve Open (scim)	0.0	15.0 max
Piston Seal Leakage, Valve Closed (scim)	0.42	40.0 max
Piston Seal Leakage, Valve Open (scim)	0.0	40.0 max
<u>Fast Shutdown Valve</u>		
Seat Leakage (scim)	0.0	10.0 max
Diaphragm Leakage (scim)	0.0	5.0 max
<u>Pressure Actuated Purge Valve</u>		
Diaphragm Leakage (scim)	0.0	3.0 max
Seat Leakage (scim)	0.0	10.0 max
<u>Engine Control Bottle</u>		
Check Valve Reverse Leakage (scim)	0.0	3.0 max

4.1.3.1 (Continued)

LOX Pressurization Control Module Check

(P/N 1B42290-503, S/N 025)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Cold Helium Shutoff Valve Seat Leakage (scim)	0.0	10.0 max
Hot Gas Valve Seat Leakage (scim)	7.4	1000.0 max

LOX Pressurization System Check Valve Checks

(P/N 1B40824-503)

<u>Check Valve Function</u>	<u>S/N</u>	<u>Reverse Leakage (scim)</u>	
		<u>Measurement</u>	<u>Limits</u>
Cold Helium Fill	131	0.0	0.0 max
LOX Prepressurization	86	0.0	0.0 max

Engine Electrical Package Checks

<u>Package Function</u>	<u>Pressure (psig)*</u>	<u>Temperature (°F)*</u>
Electrical Control Assembly Package	24.7	64.0
Auxiliary Instrumentation Package	25.0	62.0
Primary Instrumentation Package	23.5	62.0

*Limits Not Specified

4.1.4 Stage Power Setup (1B59590 E)

Prior to initiation of automatic checkouts for the stage at the STC VCL, the automatic stage power setup procedure verified the capability of the GSE automatic checkout system (ACS) to control power switching to and within the stage, and ensured that the stage power distribution system was not subjected to excessive static loads during initial setup sequences. After successful demonstration, this procedure was used to establish initial conditions during the subsequent prefire VCL automatic checkouts conducted.

This checkout was successfully demonstrated and accepted on 4 April 1967. The test started by resetting all matrix magnetic latching relays and verifying that the corresponding command relays were in the proper state. The umbilical connectors were verified to be mated, and plugs 404W26P1 and 404W27P1 were verified to be disconnected from the LOX and LH₂ inverters. Bus 4D119 talkback power was turned on and the prelaunch checkout group was turned off. The forward and aft power buses were transferred to external power. The sequencer power, engine

4.1.4 (Continued)

(Continued) 4.1.4

control bus power, engine ignition bus power, APS bus 1 and bus 2 power, and propellant level sensor power, were all verified to be off. Power to the range safety receivers and EBW firing units was transferred to external and verified to be off. The switch selector checkout indication enable and the flight measurement indication enable were both turned on. The bus 4D131 28 vdc power supply was turned on, and the forward bus 1 initial voltage and current were measured.

The range safety system safe and arm device was verified to be in the SAFE condition. Relays were verified to be reset for the engine start tank pilot valve, the LOX chilldown pilot valve, the LH₂ chilldown pump pilot valve, the auxiliary hydraulic pump flight mode, the auxiliary hydraulic pump coast mode, and the LOX flight pressurization coast period.

Power was verified to be off to the propellant utilization inverter and electronics assembly, the PCM system group, the environmental control group, and the RF group. The EBW ullage rocket relay was verified to be reset. Fifteen switch selector functions were then turned off and two were turned on. The engine cutoff indication was verified to be off, and the forward bus 1 quiescent current was measured.

After closing the cold helium supply shutoff valve, the bus 4D111 28 vdc power supply was turned on and the aft bus 1 power supply current and voltage were measured. The sequencer power was turned on, and the forward bus 1 power supply current was measured before and after turning on the PCM system group to determine its current draw. Next the bus 4D121 28 vdc power supply was turned on and the forward bus 2 power supply current and voltage were measured. The forward bus 2 power was then turned on to the prelaunch checkout group, and its current draw was measured.

The RACS system run mode was turned on, and after verifying that the forward and aft battery load tests were turned off, the DDAS ground station source select switch was manually set to position 1 and the ground station was verified to be in synchronization. A series of checks then verified that stage functions were in the proper state. Thirty-four functions were verified to be off, and

4.1.4 (Continued)

thirteen were verified to be on. The LOX and LH₂ pre valves and chilldown shutoff valves were verified to be open, and the LOX and LH₂ vent valves and fill and drain valves were verified to be closed.

The final operations of this automatic procedure measured the range safety EBW firing unit charging voltages, the aft bus 2 voltage, and the forward and aft 5 volt excitation module voltages.

No discrepancies were recorded and no FARR's were initiated. Measurement values were as shown in Test Data Table 4.1.4.1.

Three revisions were recorded in the procedure, each to correct errors in the automatic program with paper tape changes.

4.1.4.1 Test Data Table, Stage Power Setup

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Forward Bus 1 Voltage (vdc)	28.40	28 \pm 2
Forward Bus 1 Power Supply Current (amps)	0.80	40 max
Forward Bus 1 Quiescent Current (amps)	0.70	25 max
Aft Bus 1 Power Supply Current (amps)	0.70	10 max
Aft Bus 1 Voltage (vdc)	28.24	28 \pm 2
PCM System Group Current (amps)	3.00	8 max
Forward Bus 2 Voltage (vdc)	28.44	28 \pm 2
Forward Bus 2 Power Supply Current (amps)	0.80	2 max
Prelaunch Checkout Group Current (amps)	1.00	12 max
Range Safety 1 EBW Firing Unit Chg Voltage (vdc)	0.00	0 \pm 1
Range Safety 2 EBW Firing Unit Chg Voltage (vdc)	0.00	0 \pm 1
Aft Bus 2 Voltage (vdc)	0.00	0 \pm 2
Aft 5v Excitation Module Voltage (vdc)	5.02	5 \pm 0.030
Fwd 1 5v Excitation Module Voltage (vdc)	4.98	5 \pm 0.030
Fwd 2 5v Excitation Module Voltage (vdc)	4.97	5 \pm 0.030

4.1.5 Forward Skirt Thermoconditioning System Operating and Checkout Procedure (1B57599 C)

Prior to initiating prefire automatic checkout of the stage at the STC VCL, the forward skirt thermoconditioning system (TCS) was functionally checked to prepare it for operation, and then operated to demonstrate the system capability to support stage checkout operations. The procedure utilized the Model DSV-4B-359 TCS servicer, P/N 1A78829-1, which conditioned and supplied the water/methanol heat transfer fluid to the forward skirt TCS, P/N 1B38426-513..

4.1.5 (Continued)

Checkout and operation of the TCS was accomplished at the STC VCL from 5 April through 9 May 1967, and was certified as acceptable on 10 May 1967. Preliminary operations included connection of the Model DSV-4B-359 servicer to the TCS and preparation of the servicer and its associated plumbing for operation.

The first checkout conducted was the water/methanol cleanliness test for the servicer, to determine the existence of any unacceptable particulate contamination that could cause system failure through flow restriction or pump abrasion. After circulation of the water/methanol fluid through the system, fluid samples were taken from both the supply and return lines for laboratory analysis. This test was repeated later in the procedure after installation of the differential pressure (ΔP) testing equipment. All samples for both cleanliness tests were acceptable. Results indicated no particles in the 175-700 micron range, none in the 700-2500 micron range, and none above 2500 microns for any of the fluid samples checked.

Next, the water/methanol specific gravity test was conducted to ensure that the correct amounts of water and methanol had been combined for an acceptable concentration. The specific gravity and temperature of the fluid were measured with a hydrometer and thermometer, respectively, determining that the water/methanol concentration was within the acceptable mixture range (ΔP testing band).

Following the setup and installation of the ΔP test equipment, and the repeat cleanliness check, the differential pressure test was conducted to verify correct TCS system geometry and proper flow distribution. The test was conducted by measuring the differential pressure between the TCS fluid supply and return, as well as the supply and return temperatures, while maintaining a flow rate of 7.8 ± 0.3 gpm. The differential pressure was recorded as 14.75 psid, with supply and return temperatures at 52° and 54°F, respectively.

4.1.5 (Continued)

Following the successful completion of the delta P test, the automatic operation of the TCS was demonstrated using a water/methanol flow rate of 7.8 ± 0.3 gpm, a supply temperature of $80 \pm 7^\circ\text{F}$, and the maximum limits of 25 psig supply pressure and 6 psig return pressure. During this demonstration run, visual inspection for external fluid leakage from the TCS and the servicer was accomplished. No leakage was detected. Shutdown of TCS operation was followed by purging residual water/methanol from the system with GH_2 at pressures as high as 32 ± 1 psig. The TCS operation demonstrated that the system was prepared to support the stage prefire checkout activities.

There were no discrepancies recorded and no FARR's initiated as a result of this checkout.

Four revisions were recorded in the procedure.

- a. One revision authorized temporary disconnection of the servicer supply and return hose assemblies during the test to permit flowmeter calibration.
- b. One revision deleted the gaseous freon leak check of the TCS based on performing this leak check after transfer of the stage from the VCL to Test Stand Beta I for final prefire operation. Refer to paragraph 4.1.18 for results of this leak check.
- c. One revision deleted final drying requirements during GN_2 purging of the TCS, which specified dewpoint moisture checks. The basis for this revision was the immediate scheduling of the stage for transfer to Test Stand Beta I where the TCS cold plates would be promptly refilled with water/methanol fluid.
- d. One revision deleted the requirement for ensuring that the dewpoint meter was within calibration certification, since checking the TCS system dryness had also been deleted as noted above.

4.1.6 Manual Controls Check (1B70682 A)

This prefire Vehicle Checkout Laboratory (VCL) procedure verified manual control capability for the pneumatic regulators and valves in the propulsion GSE and stage systems. The test consisted of supplying electrical or pneumatic signals to system components and checking for proper response, utilizing the VCL Test Control Center (TCC) panels.

The manual controls checkout was initiated on 10 April 1967, and was completed and certified as acceptable on 21 April 1967. Preliminary GSE equipment setup operations verified that the switches and valves were set up properly for functional checks of the GSE valves and regulators.

Manual functional checks of the GSE valves and regulators followed the initial equipment setup. This included control checks of the test stand console solenoid valves, pneumatic valves, and regulators. Next the pneumatic console and stage setup was accomplished by a power turn on at the pneumatic control regulation panel, a regulator setup, and a stage power turn on. This completed preparations for the stage manual controls check.

The stage valves control check was accomplished by supplying signals manually from the VCL TCC control panels to the stage valve controls in the specified sequence, and then verifying correct talkback. In addition, test stand personnel verified stage valve actuation audibly. Starting at the mainstage propulsion manual control panel in the VCL TCC, the control helium shutoff valve was closed.

The repressurization bottle supply was opened from the mainstage checkout panel, and the control helium sphere pressure was monitored. Next, the control helium shutoff valve was opened, and the control helium regulator discharge pressure was monitored.

Using the mainstage propulsion manual control panel, the fuel and LOX tank vent valves, vent boosts, fill and drain valves, and fill and drain boosts, were individually cycled and verified. Also cycled and verified were the ambient helium sphere dump valve and the LH₂ directional vent valve.

4.1.6 (Continued)

Next, the LOX tank pressurization supply was opened from the mainstage checkout panel, pressurizing the cold helium spheres to 300 ± 50 psig. When the cold helium sphere pressure indicated 300 psig on the VMP, the LOX tank prepressurization supply was closed. Using the mainstage propulsion manual control panel, the cold helium dump valve was opened, and, after venting the cold helium sphere pressure to ambient, the dump valve was cycled closed and verified. Next, the chilldown shutoff valves and prevalues were cycled closed and open.

Using the mainstage checkout panel, the engine control supply was opened, pressurizing the engine control sphere to 300 psig, as verified on the VMP. The engine helium control supply was then closed and the engine control bottle vent valve was opened, venting the bottle to ambient prior to closing the vent valve.

The engine start bottle supply was then opened from the mainstage checkout panel, pressurizing the start bottle to 260 psig. The start tank vent valve was then opened from the mainstage propulsion manual control panel, venting the start bottle to ambient, after which the start bottle supply valve was closed.

This completed the stage manual controls check and was followed by final securing operations. The supply valves were verified to be closed from the mainstage checkout panel. The control, start, and cold helium spheres were verified to be at ambient. The regulator bleed valves were opened, and all line pressures were verified to be ambient on the mainstage and APS checkout panels. The regulator dome loader vents were opened from the pneumatic console regulation panel, and all supply and dome pressures were verified to be ambient.

There were no FARR's resulting from this checkout.

Three revisions were recorded in the procedure as follows:

- a. One revision deleted all moisture sample requirements for the pressurization spheres, based on isolation of the spheres for the VCL prefire checkout.

4.1.6 (Continued)

- b. One revision authorized re-identification of panel controls on the mainstage propulsion manual control panel, which contained certain control nomenclature applicable to Saturn S-V use only.
- c. One revision reduced the cold helium sphere pressurization limits from 500 \pm 50 psig to 300 \pm 50 psig, for compliance with temporary STC safety limitations placed on all stage pressurization spheres.

4.1.7 Cryogenic Temperature Sensor Verification (1B59818 D)

This manual procedure verified the calibration and functional capabilities of the cryogenic temperature sensors whose normal operating range did not include room ambient temperatures. The cryogenic temperature sensors, basically platinum resistance elements, changed resistance with temperature according to the Callendar-Van Dusen equation.

The test was conducted in the STC Vehicle Checkout Laboratory on 13 April 1967, and was accepted as satisfactory. As each cryogenic temperature sensor was checked, the ambient temperature at that time was measured and recorded. The procedure specified a resistance value at 32°F and a sensitivity value (change in resistance for each degree between 32°F and 100°F). With these values and the measured ambient temperature, the expected ambient resistance was calculated for each sensor. The actual ambient resistance measured was then compared to the calculated resistance with an allowable tolerance of \pm 5 percent or \pm 7 percent, depending on the sensor part number. All sensor element resistance measurements were within tolerance as listed in Test Data Table 4.1.7.1.

After the resistance of each sensor was measured, correct sensor wiring (continuity) was verified by connecting a jumper wire on the adapter cable, P/N 1B64095-1, and verifying that the sensor element for each transducer was shorted out to a resistance measurement of 5 ohms or less.

No discrepancies were noted as a result of this checkout and no revisions to the procedure were recorded.

4.1.7.1 Test Data Table, Cryogenic Temperature Sensor Verification

Measurement Number	Sensor			Resistance (Ohms)	
	P/N	S/N	Ref Loc	Meas	Limits
CO 003	1B34473-1	306	403MT686	5120	4999-5751
CO 004	1B34473-501	297	403MT687	1490	1430-1580
CO 005	1A67863-503	908	405MT612	540	513-564
CO 008	1A67863-507	1050	403MT652	1490	1430-1580
CO 009	1A67863-535	775	403MT653	213	205-225
CO 015	1A67863-509	1084	410MT603	1519	1433-1583
CO 040	1A67862-505	563	406MT613	1480	1409-1557
CO 052	1A67862-513	303	408MT612	5400	5011-5765
CO 133	NA5-27215T5	11797	4013MTT17	1385	1283-1417
CO 134	NA5-27215T5	11623	4013MTT16	1375	1283-1417
CO 157	1A67863-537	1095	404MT685	5200	4999-5751
CO 159	1A67863-519	1118	424MT610	220	205-225
CO 161	1A67863-537	878	424MT733	5160	4999-5751
CO 163	1A67863-519	1117	424MT613	217	205-225
CO 207	1A67863-503	854	425MT600	538	513-565
CO 208	1A67863-503	851	405MT605	537	512-564
CO 254	1B37878-503	1298	409MT652	1503	1433-1583
CO 255	1B37878-503	658	409MT653	1500	1433-1583

4.1.8 Level Sensor and Control Unit Calibration (1B64680 B)

This manual procedure provided the checks to determine that the control units associated with the LOX and LH₂ liquid level sensors, point level sensors, fast fill sensors, and overfill sensors, were adjusted for an operating point within the limits of the capacitance change caused by simulated wet conditions of the sensors.

Conducted in the STC VCL, the test was initiated on 18 April 1967, successfully completed on 24 April 1967, and accepted on 26 April 1967.

During the calibration test, the point level sensor manual checkout assembly, P/N 1B50928-1, was connected between each control unit and its associated level sensor, and the precision capacitor, General Radio type 1422CD, was connected in parallel with each sensor. This provided capacitance changes to each control unit to simulate wet conditions for calibration, and to determine the control unit operating points. A voltmeter was then connected to the appropriate checkout assembly test points to measure the control unit output voltage.

4.1.8 (Continued)

To establish the operating point for each sensor control unit under test, the precision capacitor was set to an appropriate capacitance to simulate a wet condition for the associated sensor. The required settings for the precision capacitor were 0.7 ± 0.01 picofarads for all LH_2 sensors except the LH_2 overfill sensor, which required 1.10 ± 0.02 picofarads, and 1.50 ± 0.02 picofarads for all LOX sensors except the LOX overfill sensor, which required 2.10 ± 0.02 picofarads. After turning on power to the individual control unit, the control unit potentiometer (R1) was adjusted until activation of the control unit was indicated by a change in output voltage from 0 ± 1 vdc to 28 ± 2 vdc. The capacitance of the precision capacitor was then decreased to obtain an output voltage of 0 ± 1 vdc, indicating relay deactivation, and again increased to obtain an output voltage of 28 ± 2 vdc, indicating relay reactivation. The deactivation and reactivation capacitance values were recorded as noted in Test Data Table 4.1.8.1.

A series of checks then verified the operation of the control unit output relay test function. With the associated sensor disconnected, each control unit output relay was verified to be deactivated under both normal and test conditions. With the sensors reconnected, the output relay for each control unit was verified to be deactivated under normal conditions and activated under test conditions.

FARR A245524 was initiated against three control units, P/N 1A68710-511, that were unstable, intermittent, and incapable of adjustment during the calibration test. The defective control units were S/N D-37 for LOX tank point level 1, S/N D-58 for LOX tank overfill, and S/N D-29 for LOX tank fast fill. These control units were replaced with S/N D-130, D-91, and D-76, respectively. Control unit, P/N 1A68710-511, S/N D-76, was later rejected by FARR A245446, for intermittent operation, and was replaced by S/N D-88. The test was then satisfactorily completed as shown in Test Data Table 4.1.8.1. No other discrepancies were noted during the test.

Sensor				Control Unit			Deact. Cap.		React. Cap.	
P/N 1A68710				P/N 1A68710			pf		pf	
Function	Ref. Loc.	Dash No.	S/N	Ref. Loc.	Dash No.	S/N	Meas.	Min.	Meas.	Max.
<u>LH₂ Tank</u>	<u>408</u>			<u>411</u>						
Liq. Lev. L1	MT634	-1	D-64	A61A217	-509	E-21	0.689	0.5	0.694	0.9
Liq. Lev. L2	MT635	-1	D-66	A61A219	-509	E-40	0.678	0.5	0.683	0.9
Pt. Lev. 1	A2C1	-507	D-22	A92A25	-509	D-58	0.644	0.5	0.646	0.9
Pt. Lev. 2	A2C2	-507	D-31	A92A26	-509	D-59	0.674	0.5	0.676	0.9
Pt. Lev. 3	A2C3	-507	D-32	A92A27	-509	D-29	0.690	0.5	0.692	0.9
Pt. Lev. 4	A2C4	-507	D-45	A61A201	-509	D-89	0.679	0.5	0.682	0.9
Fastfill	A2C5	-1	D-69	A92A43	-509	D-57	0.686	0.5	0.688	0.9
Overfill	*	*	*	A92A24	-509	D-56	1.088	0.9	1.092	1.3
<u>LOX Tank</u>	<u>406</u>			<u>404</u>						
Liq. Lev. L4	MT632	-1	D-53	A63A221	-511	D-74	1.492	1.3	1.496	1.7
Liq. Lev. L5	MT633	-1	D-56	A63A206	-511	D-73	1.470	1.3	1.477	1.7
Pt. Lev. 1	A2C1	-1	D-44	A72A1	-511	D-130	1.470	1.3	1.476	1.7
Pt. Lev. 2	A2C2	-1	D-49	A72A2	-511	E-23	1.488	1.3	1.498	1.7
Pt. Lev. 3	A2C3	-1	D-60	A72A3	-511	D-41	1.441	1.3	1.444	1.7
Pt. Lev. 4	A2C4	-1	D-68	A63A239	-511	D-105	1.466	1.3	1.471	1.7
Fastfill	A2C5	-1	D-50	A72A5	-511	D-88	1.484	1.3	1.485	1.7
Overfill	**	**	**	A72A4	-511	D-91	2.062	1.9	2.064	2.3

*Part of LH₂ Mass Probe 408A1, P/N 1A48431-505, S/N D-6
 **Part of LOX Mass Probe 406A1, P/N 1A48430-509, S/N D-6

4.1.9 Hydraulic System Servicing (1B41004 A)

Servicing the stage hydraulic system in the VCL was accomplished per this manual procedure to ensure correct filling, bleeding, and maintaining the system contaminant free after rework of the hydraulic system. Prior to pre-fire testing, the engine driven hydraulic pump thermal isolator assembly, P/N 1A86847-505, S/N 008, had been replaced with P/N 1A86847-509, S/N 043, per WRO S-IVB-3090, and the auxiliary hydraulic pump, P/N 1A66241, S/N X454673, had been reworked from the -507 to the -509 configuration by replacement of a vendor valve per WRO S-IVB-3198. The other basic components of the hydraulic system at the time of this checkout included the accumulator/reservoir assembly, P/N 1B29319-519, S/N 16, and the hydraulic actuators, P/N 1A66248-505, S/N's 56 and 57.

The servicing procedure was initiated on 26 April 1967, and was completed satisfactorily on 27 April 1967. A second issue of the procedure was conducted on 8 and 9 May 1967, after installation of the temperature probe, P/N 1B34472-503, S/N 53392, to monitor measurement number C50, the hydraulic pump inlet oil temperature. The following narrative is a description of the two issues conducted.

Prior to operation of the stage hydraulic system, the GSE and stage preliminary setups were accomplished. The GSE model DSV-4B-358 hydraulic pumping unit (HPU), P/N 1A67443, was flushed and checked for hydraulic fluid cleanliness. The HPU was connected to the stage by the pressure and return hoses, hydraulic fluid was circulated through the stage system to ensure that it was properly filled, and hydraulic fluid samples were taken and certified to be free of contamination.

The accumulator/reservoir was charged with GN₂ to 1800 \pm 50 psig. Using the HPU, system pressure was gradually increased in 500 psi increments to 4400 psig maximum while continuously checking for external leakage. No unacceptable external leakage for the stage hydraulic system was detected.

The HPU was then used to circulate hydraulic fluid through the stage hydraulic system at 1800 \pm 50 psig to flush the accumulator/reservoir. After 30 minutes of circulation at this pressure, the system was bled free of

4.1.9 (Continued)

excessive air by draining hydraulic fluid from the bleed valves at the accumulator inlet and outlet, reservoir inlet, engine driven hydraulic pump outlet, and the auxiliary hydraulic pump outlet.

The next operation was the power system flush and sample procedure, utilizing the auxiliary hydraulic pump with the hydraulic pitch and yaw actuators bypassed. The accumulator/reservoir was verified to be charged with GN₂ at 1800 ±50 psig and the auxiliary hydraulic pump air bottle at 100 to 500 psig. Using the HPU, the hydraulic system pressure was brought up to 1500 ±50 psig and then reduced to 1000 ±50 psig. The auxiliary pump was then turned on and allowed to operate for 1 minute, after successfully demonstrating that it had raised system pressure from 1000 ±50 psig to 1300 psig minimum within 5 seconds from auxiliary pump turn on. With the auxiliary pump off, system pressure was brought up to 3650 ±50 psig with the HPU and maintained for 30 seconds. Then, with system pressure reduced to between 0 and 40 psig, the engine driven hydraulic pump was flushed by manually rotating the pump quill shaft. This power system flush utilizing the auxiliary pump was repeated four times. Hydraulic fluid samples were obtained from the HPU return and pressure sample ports and determined to be within the acceptable particle count limits.

Procedures and results for both issues of this hydraulic servicing H&CO were identical, with the exception of gimbal control unit setup and hydraulic actuator midstroke lock removal prior to gimballing. This was deleted for issue 1 and accomplished by H&CO 1B41007.

No discrepancies were noted during either of the two issues for this servicing procedure, and no FARR's were initiated.

Four revisions were recorded in the procedure for issue 1 and three revisions for issue 2.

- a. Two revisions, applicable to both issues, deleted portions of the procedure not applicable to the power system fill and flush requirements for the pump component replacements.

4.1.9 (Continued)

- b. One revision for issue 1, deleted all steps involving hydraulic actuator lock removal. All steps for issue 1 were conducted with actuator locks installed at all times.
- c. One revision, for issue 1, required that the initial GN_2 accumulator charging requirements be accomplished whenever it was necessary to charge the accumulator.
- d. One revision, for issue 2, repeated the HPU setup and sampling portion of the procedure after it had become necessary to replace the servicer return hose, P/N 1B44137-1.

4.1.10 Hydraulic System Setup, Operation, and Securing (1B41007 A)

The purpose of this manual procedure was to set up the hydraulic system in preparation for the automatic system test, H&CO 1B59485 (paragraph 4.1.11), and then to shutdown and secure the hydraulic system prior to stage transfer to Test Stand Beta I. Two issues of this procedure were run in the VCL in conjunction with the hydraulic system fill, flush, bleed, and servicing procedure, H&CO 1B41004 (paragraph 4.1.9). The first issue was initiated on 27 April 1967, and was completed on 2 May 1967. Issue 1 prepared the hydraulic system for the subsequent automatic test by performing the final system air content check, the hydraulic reservoir level thermal expansion volume adjustment, the system gimbal set up, and the engine gimbal clearance check. Issue 2 was conducted on 9 May 1967, and was run to shut down the hydraulic system after completion of the automatic system test, and to secure the system prior to the stage transfer to Beta I for prefire test operations.

Components of the stage hydraulic system installed during this checkout included the engine driven hydraulic pump isolator assembly, P/N 1A86847-509, S/N 043; the auxiliary hydraulic pump, P/N 1A66241-509, S/N X454673; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 16; and the hydraulic actuators, P/N 1A66248-505, S/N's 56 and 57.

Prior to operation of the stage hydraulic system, the Model DSV-4B-358 hydraulic pumping unit (HPU), P/N 1A67443-1, was checked to ensure that the hydraulic fluid met the cleanliness requirements. The HPU was connected

4.1.10 (Continued)

to the stage via the pressure and return hoses, and hydraulic fluid was circulated through the stage system to ensure that the system was properly filled. Hydraulic fluid samples were taken and certified to be free of contamination.

The GSE Model DSV-4B-699 gimbal control unit was then setup and connected electrically to provide the electrical signals for cycling the hydraulic system gimbal actuators. After removal of the actuator midstroke locks, the GN₂ accumulator in the hydraulic system and the stage air supply bottle were charged in preparation for the engine gimbal clearance check.

The J-2 engine restrainer and bellows protective covers were removed, and the hydraulic system pressure was brought up to 1000 psig with the HPU. While observing the engine area for possible interference points, the hydraulic pitch and yaw actuators were fully extended and retracted by electrical signals from the gimbal control unit. No engine deflection clearance problem existed, and the engine was positioned to center. The actuator midstroke locks and the engine bellows protective covers were re-installed, and the gimbal control unit was disconnected from the hydraulic actuators.

The shutdown procedure prepared the hydraulic system for the automatic test, H&CO 1B59485. The shutdown sequence of this checkout included a final air content test which provided information necessary for system analysis by discharging a portion of the internal system fluid volume overboard. The volume discharged was determined to be a function of the fluid temperature measurement, to provide space in the reservoir for fluid thermal expansion under ground operating condition (0° to 160°F). The HPU was turned on and the system pressure was increased to 3650 \pm 50 psig. The bypass valve was then opened and the HPU was turned off. Verification was made that the return pressure gauge indicated a minimum of 200 psig. The shutoff valve was cycled open and closed until the return pressure was reduced to 180 \pm 5 psig. The volume of fluid bled was less than the 16 milliliters maximum specified by design requirements.

4.1.10 (Continued)

The issue 2 procedure was necessary to run the shutdown sequence and secure the system following successful completion of the hydraulic system automatic test, H&CO 1B59485 (paragraph 4.1.11).

There were no discrepancies documented by FARR's as a result of these checkouts.

Five revisions were recorded in issue 1 and one revision in issue 2, as follows:

- a. One revision deleted the VCL test control center setup requirements, based on running an engine gimbal clearance check. Setups to establish an operating curve for automatic testing were not required because the curve had been established through a formula.
- b. One revision authorized initial performance of the hydraulic system shutdown sequence to satisfy requirements of procedure 1B41004 (paragraph 4.1.9).
- c. One revision corrected a procedure error.
- d. One revision deleted the system refill section of the procedure, since no fluid loss had been experienced and the initial fill had been accomplished during the servicing procedure, H&CO 1B41004 (paragraph 4.1.9).
- e. One revision deleted the system securing and preparation for shipment in issue 1, based on the use of issue 2 for this purpose.
- f. One revision deleted all portions of issue 2 except system shutdown and securing. This was required following completion of hydraulic automatic testing, H&CO 1B59485.

4.1.11 Hydraulic System (1B59485 D)

This automatic procedure verified the integrity of the stage hydraulic system, and demonstrated the capability of the system to provide engine centering and control during powered flight. The test involved all components of the stage hydraulic system, including the main hydraulic pump thermal isolator assembly, P/N 1A86847-509, S/N 043; the auxiliary hydraulic pump, P/N 1A66241-509, S/N X454673; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 16; and the hydraulic actuators, P/N 1A66248-505, S/N's 56 and 57.

The procedure was satisfactorily accomplished on 2 May 1967, and was accepted on 23 May 1967. Those function values measured during the test are presented in Test Data Table 4.1.11.1. Except for the hydraulic pump inlet oil temperature, all of these values were acceptable and within general design requirements, although specific limit requirements were not defined in the procedure for most of the measurements.

Stage power setup was accomplished, and initial conditions were established for the test. The instrument unit (IU) 5 volt power supply was turned on and its voltage was measured, and the aft 5 volt excitation module voltage was measured. Measurements were made of various hydraulic system functions with the hydraulic system unpressurized. Measurements were also made to determine the accumulator/reservoir gaseous nitrogen mass and corrected oil level.

The methods of turning on the auxiliary hydraulic pump were checked next. During these checks, the aft bus 2 power was not turned on, so the pump itself did not actually turn on. Only the auxiliary pump on indication was checked. The coast mode operation was checked by applying dry ice to the coast mode thermal switch and verifying that the low temperature caused the thermal switch to turn the auxiliary pump on when the auxiliary hydraulic pump coast command was turned on, and that turning off the coast command turned the auxiliary pump off. The flight mode operation was checked by verifying that turning the auxiliary hydraulic pump flight command on and off properly turned the auxiliary pump on and off. The manual mode operation was checked by verifying that the auxiliary pump could be properly turned on and off at the GSE mechanical systems panel when the GSE was in the manual mode.

4.1.11 (Continued)

A sine wave generator test was satisfactorily conducted to verify proper operation of the generator. The engine centering tests were then conducted. The first test was conducted with the actuator position locks on and with the hydraulic system unpressurized. By measuring the actuator positions, and the voltage of the IU substitute 5 volt power supply and the aft 5 volt excitation module, the corrected actuator positions were determined. The pitch and yaw actuator locks were then removed, and the aft bus 2 power was turned on and the voltage was measured. The auxiliary hydraulic pump was turned on in the automatic mode, and the aft bus 2 current was measured. The increase in hydraulic system pressure over a 4 second period was measured, and the various hydraulic system functions were verified to be within their proper operating limits.

With the hydraulic system pressurized, the second engine centering test was conducted with the actuator locks off and with no excitation signal applied to the actuators. By repeating the test measurements as before, the corrected actuator positions were again determined. A zero excitation signal was then applied to the actuators, and the hydraulic system functions were measured.

A clearance, linearity, and polarity check was accomplished next. The actuators were individually extended to their stops, then retracted, causing the engine to move out to its extremes of travel, 0 degrees to $\pm 7\frac{1}{2}$ degrees, in a square pattern, counterclockwise as viewed from the engine bell. The engine was then returned to its 0 degree centered position. As the engine was sequenced through the square pattern, a clearance check verified that there was no interference to engine motion within the gimbal envelope. A comparison of the hydraulic servo engine positioning system command and response signals verified that the response movement was of the correct polarity and magnitude to agree with the command signal, and met the requirements for movement linearity.

Transient response tests were conducted next. Step commands were separately applied to the pitch and yaw actuators, causing each actuator to individually move the engine from 0 degrees to -3 degrees, from -3 degrees to 0 degrees,

4.1.11 (Continued)

from 0 degrees to +3 degrees, and from +3 degrees to 0 degrees. The engine response was observed visually and audibly for unwanted oscillations, and the actuator responses were recorded during the engine movement. The engine slew rates were manually calculated for each of the step movements. The Test Data Table shows the calculated slew rates and representative actuator response values for the initial period of each check. The values measured were all acceptable and within general design requirements, although specific limits were not discernible from the procedure.

After the transient response test was completed, final measurements were made of the hydraulic system functions and the engine centering functions with the hydraulic system pressurized, the actuator locks off, and no excitation signals applied to the actuators.

The procedure was completed by turning off the auxiliary hydraulic pump, aft bus 2, and the IU substitute 5 volt power supply. The pitch and yaw actuator locks were then replaced.

No major problems were encountered during this procedure, and no failure and rejection reports were written against the test. The hydraulic pump inlet oil temperature transducer, measurement C50, was not installed at the time of this test, as noted below in the revision discussion.

Three revisions were recorded in the procedure as follows:

- a. One revision explained the out-of-tolerance forward 5 volt excitation module voltages measured during initial conditions scan. This problem is described in the stage power setup, paragraph 4.1.15, and FARR A251516, which was made applicable to all occurrences of the problem during initial condition scan for the stage checkouts at STC.
- b. One revision explained that an out-of-tolerance C50 measurement for the hydraulic pump inlet oil temperature resulted because the transducer was not installed at the time of this test. The revision indicated the transducer would be installed and checked out during subsequent prefire tests of the hydraulic system in the VCL and on the Beta I Test Stand. This was accomplished with the installation of temperature probe, P/N 1B34472-503, S/N 53392.
- c. One revision corrected a program error.

4.1.11.1 Test Data Table, Hydraulic System

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
IU Substitute 5 volt Power Supply (vdc)	4.98	5.00 ± 0.05
Aft 5 volt Excitation Module (vdc)	5.02	5.00 ± 0.05
<u>Hydraulic System Unpressurized</u>		
Reservoir Oil Pressure (psia)	75.06	*
Accumulator GN ₂ Pressure (psia)	2370.13	*
Accumulator GN ₂ Temperature (°F)	67.83	*
Reservoir Oil Level (%)	94.56	*
Pump Inlet Oil Temperature (°F)	-69.43**	*
Reservoir Oil Temperature (°F)	100.00	*
Aft Bus 2 Current (amp)	0.20	*
Gaseous Nitrogen Mass (lb)	1.942	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	98.1	95.0 min.
<u>Engine Centering Test, Locks On, System Unpressurized</u>		
T/M Pitch Actuator Position (deg)	-0.00	*
IU Pitch Actuator Position (deg)	-0.03	*
T/M Yaw Actuator Position (deg)	0.00	*
IU Yaw Actuator Position (deg)	-0.03	*
IU Substitute 5 volt Power Supply (vdc)	4.97	*
Aft 5 volt Excitation Module (vdc)	5.02	*
Corrected T/M Pitch Actuator Position (deg)	0.025	-0.236 to 0.236
Corrected IU Pitch Actuator Position (deg)	-0.065	-0.236 to 0.236
Corrected T/M Yaw Actuator Position (deg)	-0.025	-0.236 to 0.236
Corrected IU Yaw Actuator Position (deg)	0.006	-0.236 to 0.236
Aft Bus 2 Voltage (vdc)	55.84	56.0 ± 4.0
Aft Bus 2 Current (amp)	57.20	55.0 ± 30.0
Hyd. System 4 Second Press. Change (psia)	327.3	200.0 min
<u>Engine Centering Test, Locks Off, System Pressurized, No Excitation Signal</u>		
T/M Pitch Actuator Position (deg)	-0.08	*
IU Pitch Actuator Position (deg)	-0.12	*
T/M Yaw Actuator Position (deg)	-0.06	*
IU Yaw Actuator Position (deg)	-0.04	*
IU Substitute 5 volt Power Supply (vdc)	4.97	*
Aft 5 volt Excitation Module (vdc)	5.01	*
Corrected T/M Pitch Actuator Position (deg)	-0.060	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.155	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	-0.079	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	-0.010	-0.517 to 0.517

* Limits Not Specified

** Refer to revision discussion, item b

4.1.11.1 (Continued)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
<u>Hydraulic System Pressurized, Locks Off,</u> <u>Zero Excitation Signal Applied to Actuators</u>		
Hydraulic System Pressure (psia)	3568.63	*
Reservoir Oil Pressure (psia)	164.97	*
Accumulator GN ₂ Pressure (psia)	3545.75	*
Accumulator GN ₂ Temperature (°F)	87.82	*
Reservoir Oil Level (%)	43.75	*
Pump Inlet Oil Temperature (°F)	-69.43**	*
Reservoir Oil Temperature (°F)	83.11	*
Aft Bus 2 Current (amp)	39.20	*

Pitch 0 to -3 Degree Step Response - Engine Slew Rate: 15.2 deg/sec

<u>Time from Start</u> <u>(sec)</u>	<u>Pitch Excitation</u> <u>Signal (ma)</u>	<u>IU Pitch Actuator</u> <u>Pot. Pos. (deg)</u>	<u>IU 5 volt Power</u> <u>Supply (vdc)</u>
0.000	0.000	-0.164	4.979
0.027	-19.971	-0.548	4.971
0.056	-19.971	-0.952	4.980
0.083	-19.971	-1.355	4.985
0.111	-19.971	-1.803	4.980
0.140	-19.971	-2.222	4.980
0.167	-19.922	-2.597	4.980
0.195	-19.922	-2.813	4.976
0.224	-19.971	-2.986	4.985
0.251	-19.971	-3.029	4.980
0.279	-19.971	-3.044	4.985
0.308	-19.971	-3.044	4.980

Pitch -3 to 0 Degree Step Response - Engine Slew Rate: 15.2 deg/sec

<u>Time from Start</u> <u>(sec)</u>	<u>Pitch Excitation</u> <u>Signal (ma)</u>	<u>IU Pitch Actuator</u> <u>Pot. Pos. (deg)</u>	<u>IU 5 volt Power</u> <u>Supply (vdc)</u>
0.000	-19.949	-3.134	4.979
0.025	0.000	-2.654	4.980
0.054	-0.049	-2.236	4.980
0.083	-0.098	-1.817	4.980
0.110	0.000	-1.342	4.980
0.139	-0.049	-0.938	4.980
0.167	0.000	-0.548	4.980
0.193	0.000	-0.317	5.000
0.222	0.000	-0.216	4.980
0.250	-0.098	-0.158	4.985
0.277	0.000	-0.158	4.980
0.306	0.000	-0.188	4.980

* Limits Not Specified

** Refer to revision discussion, item b

4.1.11.1 (Continued)

Pitch 0 to +3 Degree Step Response - Engine Slew Rate: 15.2 deg/sec

<u>Time from Start (sec)</u>	<u>Pitch Excitation Signal (ma)</u>	<u>IU Pitch Actuator Pot. Pos. (deg)</u>	<u>IU 5 volt Power Supply (vdc)</u>
0.000	-0.050	-0.119	4.984
0.027	19.775	0.419	4.980
0.055	19.971	0.809	4.980
0.083	19.922	1.256	4.980
0.111	19.922	1.718	4.985
0.139	19.873	2.121	4.985
0.167	19.922	2.497	4.990
0.195	19.922	2.670	4.980
0.223	19.922	2.800	4.980
0.251	19.873	2.828	4.980
0.279	19.873	2.828	4.985
0.307	19.873	2.814	4.980

Pitch +3 to 0 Degree Step Response - Engine Slew Rate: 15.2 deg/sec

<u>Time from Start (sec)</u>	<u>Pitch Excitation Signal (ma)</u>	<u>IU Pitch Actuator Pot. Pos. (deg)</u>	<u>IU 5 volt Power Supply (vdc)</u>
0.000	19.899	2.955	4.984
0.026	0.000	2.453	4.980
0.055	0.000	2.121	4.980
0.083	0.146	1.674	4.980
0.110	-0.049	1.213	4.980
0.139	-0.146	0.794	4.980
0.167	0.049	0.448	4.980
0.194	0.000	0.202	4.980
0.223	-0.049	0.044	4.980
0.251	0.000	-0.071	4.980
0.278	-0.049	-0.071	4.980
0.307	0.000	-0.086	4.980

Yaw 0 to -3 Degree Step Response - Engine Slew Rate: 15.2 deg/sec

<u>Time from Start (sec)</u>	<u>Yaw Excitation Signal (ma)</u>	<u>IU Yaw Actuator Pot. Pos. (deg)</u>	<u>IU 5 volt Power Supply (vdc)</u>
0.000	0.050	-0.090	4.979
0.027	-19.824	-0.563	4.980
0.056	-19.824	-0.996	4.976
0.083	-19.873	-1.443	4.980
0.111	-19.873	-1.905	4.980
0.140	-19.873	-2.353	4.985
0.167	-19.824	-2.670	4.980
0.195	-19.873	-2.915	4.980
0.224	-19.873	-3.002	4.980
0.251	-19.922	-3.045	4.985
0.279	-19.873	-3.017	4.980
0.308	-19.873	-3.060	4.980

4.1.11.1 (Continued)

Yaw -3 to 0 Degree Step Response - Engine Slew Rate: 15.2 deg/sec

<u>Time from Start (sec)</u>	<u>Yaw Excitation Signal (ma)</u>	<u>IU Yaw Actuator Pot. Pos. (deg)</u>	<u>IU 5 volt Power Supply (vdc)</u>
0.000	-19.850	-3.180	4.994
0.026	0.098	-2.670	4.980
0.055	0.049	-2.251	4.980
0.083	0.049	-1.790	4.980
0.110	0.049	-1.299	4.980
0.139	0.049	-0.852	4.980
0.167	0.098	-0.506	4.980
0.194	0.049	-0.260	4.980
0.223	0.098	-0.145	4.985
0.251	0.098	-0.087	4.985
0.278	0.098	-0.044	4.985
0.306	0.146	-0.059	4.971

Yaw 0 to +3 Degree Step Response - Engine Slew Rate: 15.2 deg/sec

<u>Time from Start (sec)</u>	<u>Yaw Excitation Signal (ma)</u>	<u>IU Yaw Actuator Pot. Pos. (deg)</u>	<u>IU 5 volt Power Supply (vdc)</u>
0.000	0.100	-0.015	4.984
0.027	19.922	0.433	4.980
0.056	19.922	0.865	4.980
0.083	19.971	1.327	4.976
0.111	19.922	1.803	4.980
0.140	19.971	2.265	4.980
0.167	19.873	2.611	4.980
0.195	19.922	2.827	4.980
0.224	19.922	2.943	4.980
0.251	19.971	2.972	4.980
0.279	19.922	2.986	4.980
0.308	19.922	2.986	4.980

Yaw +3 to 0 Degree Step Response - Engine Slew Rate: 15.2 deg/sec

<u>Time from Start (sec)</u>	<u>Yaw Excitation Signal (ma)</u>	<u>IU Yaw Actuator Pot. Pos. (deg)</u>	<u>IU 5 volt Power Supply (vdc)</u>
0.000	19.949	3.074	4.979
0.026	0.146	2.539	4.980
0.055	0.098	2.135	4.985
0.083	0.098	1.659	4.980
0.110	0.000	1.197	4.980
0.139	0.098	0.735	4.985
0.166	0.098	0.360	4.980
0.193	0.049	0.144	4.971
0.224	0.000	0.014	4.980
0.250	0.098	-0.044	4.985
0.278	0.098	-0.029	4.980
0.307	0.098	0.014	4.980

4.1.11.1 (Continued)

Final Hydraulic System and Engine Centering Test System Pressurized, Locks Off, No Excitation Signal

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Hydraulic System Pressure (psia)	3568.63	*
Reservoir Oil Pressure (psia)	170.21	*
Accumulator GN ₂ Pressure (psia)	3553.94	*
Accumulator GN ₂ Temperature (°F)	74.88	*
Reservoir Oil Level (%)	42.14	*
Pump Inlet Oil Temperature (°F)	-69.43**	*
Reservoir Oil Temperature (°F)	98.43	*
Aft Bus 2 Current (amps)	40.60	*
T/M Pitch Actuator Position (deg)	-0.07	*
IU Pitch Actuator Position (deg)	-0.07	*
T/M Yaw Actuator Position (deg)	-0.09	*
IU Yaw Actuator Position (deg)	-0.09	*
IU Substitute 5 volt Power Supply (vdc)	4.98	*
Aft 5 volt Excitation Module (vdc)	5.01	*
Corrected T/M Pitch Actuator Position (deg)	-0.044	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.103	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	-0.110	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	-0.062	-0.517 to 0.517

* Limits Not Specified

** Refer to revision discussion, item b

4.1.12 Digital Data Acquisition System Calibration (1B59593 E)

The automatic calibration of the digital data acquisition system (DDAS) was accomplished during this checkout through the insertion of analog signals to the multiplexer inputs and sending discrete signals to the DDAS bi-level inputs. This test verified that the DDAS was ready to proceed with stage post storage checkout operations. The items involved in this test were the PCM/DDAS assembly, P/N 1A74049-511, S/N 5; the CP1-BO time division multiplexer, P/N 1B62513-531, S/N 017; the DP1-BO time division multiplexer, P/N 1B62513-533, S/N 03; the remote digital submultiplexer (RDSM), P/N 1B52894-1, S/N 09; and the low level remote analog submultiplexer (RASM), P/N 1B54062-503, S/N 012.

Assembly outline 1B57693R had replaced the CP1-BO and DP1-BO multiplexers, P/N 1B62513-515, S/N 03, and P/N 1B62513-517, S/N 02, with configuration -531 and -533 multiplexers, respectively, prior to initiation of this test.

4.1.12 (Continued)

Initiated on 5 May 1967, the calibration was successfully completed on 8 May 1967, and was accepted on 9 June 1967. Prior to automatic testing, manual checks of the 72 kHz bit rate and 600 kHz VCO deviation were accomplished. The 72 kHz bit rate test checked the clock output of the PCM data train with a frequency counter to ensure that the frequency was within the required tolerance of 71,975 to 72,025 bits per second. The 600 kHz VCO test was accomplished by measuring the band edge frequencies and voltages of the PCM/DDAS VCO output. The upper band edge frequency was measured as 633.667 kHz at 2.55 vrms, within the acceptable limits of 623.2 kHz to 643.2 kHz at greater than 2.2 vrms. The lower band edge frequency was measured as 567.067 kHz at 2.77 vrms, within the acceptable limits of 556.8 kHz to 576.8 kHz at greater than 2.2 vrms. The frequency differential was calculated as 66.600 kHz, within the acceptable limits of 60 to 80 kHz.

Stage power was turned on and initial conditions were established. The DDAS ground station was verified to be in synchronization with the stage DDAS, and testing proceeded with the automatic flight calibration of the CP1-BO and DP1-BO multiplexers. The outputs of data channels DP1-BO-11-01 through -11-10 and CP1-BO-11-01 through -11-10 were recorded at each of the calibration input levels of 0.000, 1.250, 2.500, 3.750 and 5.000 vdc. The output of each of these channels was within the ± 0.030 vdc tolerance limit of the input for each calibration level.

The CP1-BO and DP1-BO multiplexers were then checked individually. For testing of each multiplexer, the required manual test cable connections were made; and when called for by the computer typeout, the multiplexer input signal power supply was adjusted to voltage levels of 0.000, 1.250, 2.500, 3.750, and 5.000 vdc ± 0.001 vdc for the five test runs on each multiplexer. During the 0.000 vdc input level test run only, input voltages of 4.5 ± 0.100 vdc and 20.0 ± 1.0 vdc were supplied to the PCM/DDAS assembly. The PCM/DDAS input voltages were 0.0 ± 0.100 vdc and 0.0 ± 1.0 vdc, respectively, during the other four test runs. The CP1-BO multiplexer tests were repeated due to channel malfunctions resulting from operator setup error. All channel outputs for the repeat CP1-BO tests and the DP1-BO multiplexer tests were verified to be within the required tolerances of ± 0.025 vdc or ± 0.03 vdc, as applicable.

4.1.12 (Continued)

The remote digital submultiplexer (RDSM) was checked by inserting signal levels equivalent to ones (20 vdc) and zeros (0 vdc) into the RDSM input circuits and checking the output at the computer for a digital word of corresponding ones and zeros. The remote analog submultiplexer (RASM) was tested by inserting signal voltages, 0 to 30 millivolts, which were amplified to an output range of 0 to 5 volts dc in correspondence with the 0 to 30 millivolt range input. All measured outputs for the RDSM were within the required tolerances. The RASM test was repeated, as channel malfunctions on the first test indicated out-of-tolerance measurements. This occurred due to program errors. After program error correction, all measured outputs for the RASM were within the required tolerances during the repeat test. The final test measured the PCM/FM transmitter current at 4.5 amperes, within the allowable limits of 4.5 ± 3.0 amperes.

There were no part shortages affecting the test, and no problems resulting in FARR initiation.

Eight revisions were recorded in the procedure as follows.

- a. Three revisions corrected program errors, two which involved the channel malfunctions during initial RASM testing as described previously.
- b. Two revisions corrected operator setup errors that had resulted in channel malfunctions, and then repeated the tests. One error was a failure to hook up the PCM RF assembly for the PCM/FM transmitter current test. The other setup error resulted in the out-of-tolerance initial tests of the CP1-B0 multiplexer as noted previously.
- c. One revision explained the out-of-tolerance forward 5 volt excitation module voltages measured during initial conditions scan. This problem is described in detail in the stage power setup, paragraph 4.1.15, and is also noted in the power distribution system paragraph 4.1.22. This revision also referred to FARR A251516 which is discussed in 4.1.15.
- d. One revision authorized a substitution for the power supply in the RASM test setup. The specified EPSCO unit, P/N VR607-2, did not exhibit sufficient stability to meet the ± 0.015 mvdc tolerance on RASM input power.
- e. One revision noted that a LOX chilldown shutoff valve not open indication during initial conditions scan resulted from disconnection of the valve. This was accepted since DDAS calibration testing was not affected.

4.1.13 Stage Power Turnoff (1B59591 D)

The stage power turnoff procedure was used for automatic shutdown of the stage power distribution system, returning the stage to the de-energized condition after completion of the various system checkout procedures during prefire testing of the stage at the VCL. The procedure deactivated stage relays so that no current flowed from the battery simulators through the stage wiring. All internal/external transfer relays were set to the external condition.

Satisfactory demonstration of this procedure was accomplished and accepted on 9 May 1967. Stage power turnoff measurement values for this demonstration issue are tabulated in Test Data Table 4.1.13.1. Following this, the stage power turnoff procedure was used to shutdown the stage at the conclusion of the various automatic checkouts conducted during VCL prefire operations.

Automatic stage power turnoff started with verification that the umbilical connectors were mated and that the flight measurement indication enable was turned on. The bus 4D119 talkback power, the forward bus 1 and aft bus 1 28 vdc power supplies, and the sequencer power were all verified to be on. The forward bus 1 and aft bus 1 voltages were then measured.

Switch selector functions were then turned off, and a series of checks verified that the stage electrical functions were in the proper state of off or reset. The forward and aft bus power supplies were verified as off, and the forward and aft bus battery simulator voltages were measured. Stage buses were then transferred to external power, and the forward and aft stage bus voltages were measured. The EBW pulse sensor power was turned off, and the range safety receivers and EBW firing units were transferred to external power. The range safety system safe and arm device was verified to be on safe, and the bus 4D119 talkback power was turned off. The matrix magnetic latching relays were then reset, completing this demonstration run for stage power turnoff.

There were no discrepancies recorded by FARR's against this test, and no revisions were recorded in the procedure.

4.1.13.1 Test Data Table, Stage Power Turnoff

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Forward Bus 1 Voltage, Power On (vdc)	29.04	28 \pm 2
Aft Bus 1 Voltage, Power On (vdc)	29.08	28 \pm 2
Forward Bus 1 Battery Simulator Voltage (vdc)	0.00	0 \pm 2
Forward Bus 2 Battery Simulator Voltage (vdc)	0.00	0 \pm 2
Aft Bus 1 Battery Simulator Voltage (vdc)	0.00	0 \pm 2
Aft Bus 2 Battery Simulator Voltage (vdc)	0.00	0 \pm 2
Forward Bus 1 Voltage, Power Off (vdc)	0.08	0 \pm 1.0
Forward Bus 2 Voltage, Power Off (vdc)	0.00	0 \pm 1.0
Aft Bus 1 Voltage, Power Off (vdc)	-0.04	0 \pm 1.0
Aft Bus 2 Voltage, Power Off (vdc)	0.00	0 \pm 1.0

4.1.14 Umbilical Interface Compatibility Check (1B64306 D)

The umbilical interface compatibility was checked out at Test Stand Beta I per this procedure prior to connecting the umbilical cables for stage power turn on. The design specifications and continuity of the stage umbilical wiring was checked out by point-to-point resistance checks of all umbilical circuits. This test assured that proper loads were present on all power buses and that the control circuits for propulsion valves and safety items on the stage were within the prescribed tolerances.

This checkout at Beta I was initiated and satisfactorily completed on 16 May 1967. A series of resistance measurements was made at specified test points on the GSE Model DSV-4B-133 signal distribution unit, P/N 1A59949, using test point/terminal 463A1A5-J34FF as the common point for all measurements. These measurements verified that all wires and connections in the umbilical cables and stage umbilical wiring were intact and of the proper material and wire gauge, and that all resistance values and loads were within acceptable limits. A Simpson Model 260 multimeter and a Triplet Model 630 multimeter were used to make the resistance measurements. See Test Data Table 4.1.14.1 for particular test points, circuit functions, measured resistances, and resistance limits.

No discrepancies were recorded during checkout and no FARR's were initiated.

4.1.14 (Continued)

Four revisions were recorded in the procedure, each of which authorized changes in allowable tolerances for the following resistance measurements.

<u>Test Point</u>	<u>Limit (Ohms)</u>		<u>Reason for Revision</u>
	<u>Specified</u>	<u>Revised</u>	
A2J29-h	50 max	300 max	Resistance limits increased by cable configurations incorporating diodes.
b. A2J29-i	50 max	10-80	Same as Item a. above
A2J30-W	10-60	10-80	
A2J30-X	10-60	10-80	
A2J30-Z	10-60	10-80	
c. A2J42-F	1.0K min	100-200	Deletion of the stage LH ₂ timer and replacement with relay coils lowered aft bus 1 resistance.
d. A2J30-b	10-30	10-40	Limits recalculated based on Engineering evaluation indicating tolerances were too stringent.
A2J30-c	10-30	10-40	
A2J30-d	10-30	10-40	
A2J30-e	10-30	10-40	

4.1.14.1 Test Data Table, Umbilical Interface Compatibility Check

Reference Designation 463A2

<u>Test Point</u>	<u>Function</u>	<u>Meas. Ohms</u>	<u>Limit Ohms</u>
A2J29-C	Cmd., Ambient Helium Sphere Dump	27	10-60
CB-8-2	Cmd., Engine Ignition Bus Power Off	Inf.	Inf.
CB-9-2	Cmd., Engine Ignition Bus Power On	9	5-20
CB-10-2	Cmd., Engine Control Bus Power Off	Inf.	Inf.
CB-11-2	Cmd., Engine Control Bus Power On	10	5-20
A2J29-N	Cmd., Engine He Emerg Vent Control On	55	10-60
A2J29-Y	Cmd., Start Tk Vent Pilot Vlv Open	23	10-60
CB-4-2	Cmd., LOX Tk Cold He Sphere Dump	34	10-60
A2J29-h	Cmd., Fuel Tk Vent Pilot Vlv Open	250	300 max
	(Same, reverse polarity)	Inf.	500K min
A2J29-i	Cmd., Fuel Tk Vent Vlv Boost Close	70	10-80
	(Same, reverse polarity)	Inf.	500K min
A2J29-g	Cmd., Ambient He Sup Shutoff Valve Close	25	10-60
A2J30-H	Cmd., Cold He Sup Shutoff Valve Close	1.3K	1.5K max
	(Same, reverse polarity)	Inf.	Inf.
A2J30-W	Cmd., LOX Vent Valve Open	70	10-80
A2J30-X	Cmd., LOX Vent Valve Close	70	10-80
A2J30-Y	Cmd., LOX & Fuel Prevlv Emerg Close	70	100 max
	(Same, reverse polarity)		
A2J30-Z	Cmd., LOX & Fuel Chlldown Vlv Close	70	10-80
A2J30-b	Cmd., LOX Fill & Drain Valve Boost Close	33	10-40
A2J30-c	Cmd., LOX Fill & Drain Valve Open	33	10-40
A2J30-d	Cmd., Fuel Fill & Drain Valve Boost Close	33	10-40
A2J30-e	Cmd., Fuel Fill & Drain Valve Open	33	10-40
A2J42-F	Meas., Bus +4D111 Regulation	175	100-200
A2J35-y	Meas., Bus +4D141 Regulation	650	50 min
A2J6-AA	Sup., 28v Bus +4D119 Talkback Power	100	60-100

Reference Designation 463A1

A5J41-A	Meas., Bus +4D131 Regulation	1.5K	400 min
A5J41-E	Meas., Bus +4D121 Regulation	2.3K	1.6K min
A5J53-AA	Sup., 28v +4D119 Fwd Talkback Power	70	60-100

4.1.15 Stage Power Setup (1B59496 D)

Prior to initiation of automatic prefire checkouts for the stage on Test Stand Beta I, the automatic stage power setup procedure verified the capability of the GSE Automatic Checkout System (ACS) to control power switching to and within the stage, and ensured that the stage power distribution system was not subjected to excessive static loads during initial setup sequences. After successful demonstration, this procedure was used to establish initial conditions during the subsequent prefire automatic stage checkouts conducted at Beta I.

This checkout was successfully demonstrated on 16 May 1967, and was accepted on 17 May 1967. Stage power setup measured values were as shown in Test Data Table 4.1.15.1.

The test started by resetting all matrix magnetic latching relays and verifying that the corresponding command relays were in the proper state. The umbilical connectors were verified to be mated, and plugs 404W26P1 and 404W27P1 were verified to be disconnected from the LOX and LH₂ inverters. The bus 4D119 talkback power was turned on and the prelaunch checkout group power was turned off. The forward and aft power buses were transferred to external power. The sequencer power, engine control bus power, engine ignition bus power, APS bus 1 and bus 2 power, and propellant level sensor power, were all verified to be off. Power to the range safety receivers and EBW firing units was transferred to external and verified to be off. The switch selector checkout indication enable and the flight measurement indication enable were both turned on. The bus 4D131 28 vdc power supply was turned on and the forward bus 1 initial current and voltage were measured.

The range safety system safe and arm device was verified to be in the safe condition. Twenty-seven switch selector functions were then turned off and four were turned on. The forward bus 1 quiescent current was measured, power was turned on to the PCM system group and the current was measured.

After closing the cold helium supply shutoff valve, the bus 4D111 28 vdc supply was turned on and the aft bus 1 power supply current and voltage were measured. The sequencer power was then turned on, and the aft bus 1 power

4.1.15 (Continued)

supply current was remeasured to compute the current draw. Next, the bus 4D121 28 vdc power supply was turned on and the forward bus 2 power supply current and voltage were measured. The forward bus 2 power was then turned on to the prelaunch checkout group and the current was measured.

The RACS system run mode was turned on, and, after verifying that the forward and aft battery load tests were turned off, the DDAS ground station source selector switch was manually set to position 1 and the ground station was verified to be in synchronization. A series of checks then verified that stage functions were in the proper state. Forty-one functions were verified to be off and twenty were verified to be on. The LOX and LH₂ prevalues and chilldown shutoff valves were verified to be open, and the LOX and LH₂ vent valves and fill and drain valves were verified to be closed.

The final operations of this automatic procedure measured the forward and aft 5 volt excitation module voltages, the range safety EBW firing unit charging voltages, the aft bus 2 voltage, the forward and aft battery simulator voltages, and the component test power voltage.

One discrepancy was recorded on FARR A251516. The measured values for the forward 1 and 2 5 volt excitation module voltages were out-of-tolerance as listed in the Test Data Table. The low voltage indications were caused by a 30 millivolt line drop on the ground return of the expanded scale module. The return line for this module shares the signal conditioning rack power. return line, and the signal conditioning current produced the large line loss. As the 5 volt excitation modules had been properly adjusted to the specified tolerance of 5.0 ± 0.030 volts, the out-of-tolerance measurements for the voltage monitoring circuits were acceptable to Engineering, as noted on FARR A251516. Resolution of the problem was offered through a change in calibration curves based on system calibration data obtained from studies at SSC.

Three revisions were recorded in the procedure as follows:

- a. One revision explained the out-of-tolerance forward 5 volt excitation module voltages, as described previously for FARR A251516.

4.1.15 (Continued)

- b. One revision authorized an ALCO change to the program tolerance for the prelaunch checkout group current draw. The tolerance was changed from 8 ± 4 to 4 ± 4 amps. The tolerance of 8 ± 4 amps was considered a program error because normal current for the prelaunch checkout group could have been as low as 2 amps.
- c. One revision explained an indication of noise input on channel 5 during printout of range time at the beginning of stage power setup. The noise indication resulted from a timing problem in the Model DSV-4B-118 computer interface unit, P/N 1A59937-1, when an SSD slide was manually selected while the computer was asking for range time.

4.1.15.1 Test Data Table, Stage Power Setup

<u>Function</u>	<u>Measurement</u>	<u>Limit</u>
Forward Bus 1 Initial Current (amps)	0.90	20 max.
Forward Bus 1 Voltage (vdc)	28.44	29 ± 2
Forward Bus 1 Quiescent Current (amps)	1.50	5 max
PCM System Group Current (amps)	3.80	5 ± 3
Aft Bus 1 Power Supply Current (amps)	0.40	2 max.
Aft Bus 1 Voltage (vdc)	28.64	28 ± 2
Sequencer Power (amps)	0.00	3 max.
Forward Bus 2 Power Supply Current (amps)	0.80	2 max.
Forward Bus 2 Voltage (vdc)	28.00	28 ± 2
Prelaunch Checkout Group Current (amps)	2.00	4 ± 4
Aft 5 V Excitation Module Voltage (vdc)	5.02	5.0 ± 0.030
Forward 1 5 V Excitation Module Voltage (vdc)	4.97*	5.0 ± 0.030
Forward 2 5 V Excitation Module Voltage (vdc)	4.96*	5.0 ± 0.030
Range Safety 1 EBW Firing Unit Chg Voltage (vdc)	0.01	0 ± 1
Range Safety 2 EBW Firing Unit Chg Voltage (vdc)	0.00	0 ± 1
Aft Bus 2 Voltage (vdc)	0.00	0 ± 1
Forward Battery 1 Voltage (vdc)	0.04	0 ± 1
Forward Battery 2 Voltage (vdc)	0.00	0 ± 1
Aft Battery 1 Voltage (vdc)	0.00	0 ± 1
Aft Battery 2 Voltage (vdc)	0.00	0 ± 1
Component Test Power Voltage (vdc)	0.56	0 ± 1

*Out-of-tolerance, reference FARR A251516

4.1.16 Stage Power Turnoff (1B59497 D)

The stage power turnoff procedure was used for automatic shutdown of the stage power distribution system, returning the stage to the de-energized condition after completion of the various system checkout procedures during prefire testing of the stage on Test Stand Beta I. The procedure deactivated stage relays so that no current flowed from the battery simulators through the stage wiring. All internal/external transfer relays were set to the external condition.

4.1.16 (Continued)

Satisfactory demonstration of this procedure was accomplished and accepted on 16 May 1967. Stage power turnoff measurement values for this demonstration issue are tabulated in Test Data Table 4.1.16.1. Following this, the stage power turnoff procedure was used to shut down the stage at the conclusion of the various automatic checkouts conducted during Beta I prefire operations.

The automatic stage power turnoff started with a verification that the umbilical connectors were mated and that the flight measurement indication enable was turned on. The bus 4D119 talkback power, the forward bus 1 and aft bus 1 28 vdc power supplies, and the sequencer power were all verified to be on. The forward bus 1 and aft bus 1 voltages were then measured.

Switch selector functions were then turned off and a series of checks verified that the stage electrical functions were in the proper state of off or reset. The forward and aft bus power supplies were verified as off, and the forward and aft bus battery simulator voltages were measured. Stage buses were then transferred to external power, and the forward and aft stage bus voltages were measured. The EBW pulse sensor power was turned off, and the range safety receivers and EBW firing units were transferred to external power. The range safety system safe and arm device was verified to be on safe, and the bus 4D119 talkback power was turned off. The matrix magnetic latching relays were then reset, completing this demonstration run for stage power turnoff.

There were no discrepancies recorded by FARR's against this test, and no revisions were recorded in the procedure.

4.1.16.1 Test Data Table, Stage Power Turnoff

<u>Function</u>	<u>Measurement</u>	<u>Limit</u>
Forward Bus 1 Voltage, Power On (vdc)	28.48	28 \pm 2
Aft Bus 1 Voltage, Power On (vdc)	28.48	28 \pm 2
Forward Bus 1 Battery Simulator Voltage (vdc)	0.04	0 \pm 2
Forward Bus 2 Battery Simulator Voltage (vdc)	0.00	0 \pm 2
Aft Bus 1 Battery Simulator Voltage (vdc)	0.00	0 \pm 2
Aft Bus 2 Battery Simulator Voltage (vdc)	0.16	0 \pm 2
Forward Bus 1 Voltage, Power Off (vdc)	0.16	0 \pm 1.0
Forward Bus 2 Voltage, Power Off (vdc)	0.00	0 \pm 1.0
Aft Bus 1 Voltage, Power Off (vdc)	0.08	0 \pm 1.0
Aft Bus 2 Voltage, Power Off (vdc)	0.08	0 \pm 1.0

4.1.17 Forward Skirt Thermoconditioning System Operating and Checkout Procedure (1B41955 A)

Prior to initiating prefire automatic checkout of the stage at the STC Test Stand Beta I, the forward skirt thermoconditioning system (TCS) was functionally checked to prepare it for operation, and then operated to demonstrate that the system was capable of supporting stage checkout operations. The procedure utilized the Model DSV-4B-359 TCS servicer, P/N 1A78829-1, which conditioned and supplied the water/methanol heat transfer fluid to the forward skirt TCS, P/N 1B38426-513.

Checkout and operation of the TCS was initiated at the STC Test Stand on 16 May 1967, and was completed on 3 June 1967. Preliminary operations included connection of the Model DSV-4B-359 servicer to the TCS, and preparation of the servicer and its associated plumbing for operation.

The first checkout conducted was the water/methanol cleanliness test for the servicer, to determine the existence of any unacceptable particulate contamination that could cause system failure through flow restriction or pump abrasion. After circulation of the water/methanol fluid through the system, fluid samples were taken from both the supply and return lines for laboratory analysis. This test was repeated later in the procedure after installation of the differential pressure (ΔP) testing equipment. All samples for both cleanliness tests were acceptable. Results indicated no particles in the 175-700 micron range, none in the 700-2500 micron range, and none above 2500 microns for any of the fluid samples checked.

Next, the water/methanol specific gravity test was conducted to ensure that the correct amounts of water and methanol had been combined for an acceptable concentration. The specific gravity and temperature of the fluid were measured with a hydrometer and thermometer, respectively, determining that the water/methanol concentration was within the acceptable mixture range (ΔP testing band).

Following the setup and installation of the ΔP test equipment, and the repeat cleanliness check, the differential pressure test was conducted to verify correct TCS system geometry and proper flow distribution. The test was

4.1.17 (Continued)

conducted by measuring the differential pressure between the TCS fluid supply and return, as well as the supply and return temperatures, while maintaining a flow rate of 7.8 ± 0.2 gpm. The differential pressure was recorded as 14.75 psid, with supply and return temperatures at 68°F and 76°F, respectively.

Following the successful completion of the delta P test, the automatic operation of the TCS was demonstrated using a water/methanol flow rate of 7.8 ± 0.2 gpm, a supply temperature of $85 \pm 5^\circ\text{F}$, and the maximum limits of 20 ± 2 psig supply pressure and 6 psig return pressure. During this demonstration run, visual inspection for external fluid leakage from the TCS and the servicer was accomplished. No leakage was detected. Shutdown of TCS operation was followed by purging residual water/methanol from the system with GH_2 at pressures as high as 32 ± 1 psig. The TCS operation demonstrated that the system was prepared to support the stage prefire checkout activities.

Four revisions were made to this procedure:

- a. One revision added a requirement to run four paragraphs of H&CO 1B41884, to dry the stage cold plates prior to performing the leak check with freon.
- b. One revision changed the wording of a paragraph from "The flowmeter shall indicate 7.8 ± 0.2 gpm" to "The flowmeter shall indicate 7.8 ± 0.2 gpm per the calibration curve."
- c. Two revisions deleted requirements for time cycle data recording in this procedure.

There were no failures documented and all parts were installed at the start of this test.

No modification or rework effort was anticipated that would invalidate the results of this test and the thermoconditioning system was accepted for use.

4.1.18 Stage and GSE Manual Controls Check (1B70177 D)

This prefire procedure verified manual control capability for the pneumatic regulators and valves in the propulsion GSE and stage systems. The test

4.1.18 (Continued)

consisted of supplying electrical and pneumatic signals to system components and checking for proper response, utilizing the Beta I Test Control Center (TCC) panels.

The manual controls checkout was initiated on 17 May 1967, and was completed and certified as acceptable on 10 June 1967. Preliminary GSE equipment setup operations were initiated to verify that the switches and valves were set up properly for functional checks of the GSE valves and regulators.

Manual functional checks of the GSE valves and regulators followed the initial equipment setup. This included control checks of the test stand console solenoid and pneumatic valves, the nitrogen regulator controls, the skid valve controls, the auxiliary pressurization controls, the helium regulator controls, and the hydrogen regulator controls.

A stage setup and control helium system check preceded the stage valves control check. The stage purge hand valves were verified to be closed, and the LH₂ and LOX repressurization spheres were verified to be isolated per H&CO 1B70422. The control helium sphere was pressurized to 100 psig and a pressure decay check was performed. The control helium shutoff valve was opened, the control helium bottle fill valve was opened, and the control helium regulator discharge pressure was verified to be stabilized at 500 psig at the test stand VMP and at the TCC vehicle supply panel.

The stage valves control check was accomplished by supplying signals manually from the Beta I TCC control panels to the stage valve controls in the specified sequence, and then verifying correct talkback. In addition, test stand personnel verified stage valve actuation audibly or by touch. Starting at the TCC mainstage propulsion manual control panel, the LH₂ and LOX chilldown shutoff valves and the LH₂ and LOX prevalues were individually cycled and verified. At the TCC LH₂ control panel, the LH₂ tank vent and the fill and drain valves were cycled open and closed. The LH₂ tank vent boost close and the fill and drain boost close were cycled. The LH₂ directional vent was

4.1.18 (Continued)

cycled from flight to ground position. Using the TCC LOX control panel, the LOX tank vent and the fill and drain valves were cycled open and closed. The LOX tank vent boost close and the fill and drain boost close were cycled. The cold helium shutoff valve was cycled open and closed. Valves cycled from the TCC stage supply panel included the engine control bottle dump, the cold helium bottle dump, the start tank dump, and the LOX and LH₂ repressurization dump valves. The control helium bottle fill valve was then closed.

The stage valves control check was completed at the TCC repressurization control panel by cycling the O₂H₂ burner LOX and LH₂ propellant valves, and the LOX shutdown valve.

The final portion of the procedure consisted of the LH₂ and LOX umbilical purge interlock check, using the TCC LH₂ and LOX control panels.

The test was terminated by securing the test stand pneumatic systems, using the Beta I TCC control panels and the test stand pneumatics consoles.

There were no FARR's attributed to stage controls resulting from this checkout.

Two revisions were recorded in the procedure dealing with stage controls checks. Both corrected typographical errors as follows:

- a. One revision noted that those paragraphs dealing with propellant tank repressurization and gaseous nitrogen ejector control were not applicable to the Saturn IB configuration.
- b. One revision corrected the H&CO number and paragraph reference required to functionally check the control helium shutoff valve backup pressure switch.

4.1.19 Cryogenic Temperature Sensor Verification (1B63146 A)

This manual procedure verified the calibration and functional capabilities of the cryogenic temperature sensors whose normal operating range did not include room ambient temperatures. The cryogenic temperature sensors, basically platinum resistance elements, changed resistance with temperature according to the Callendar-Van Dusen equation.

4.1.19 (Continued)

The checkout was conducted and accepted as satisfactory on 17 May 1967. As each cryogenic temperature sensor was checked, the ambient temperature at that time was measured and recorded. The procedure specified a resistance value at 32°F and a sensitivity value (change in resistance for each degree between 32°F and 100°F). With these values and the measured ambient temperature, the expected ambient resistance was calculated for each sensor. The actual ambient resistance measured was then compared to the calculated resistance with an allowable tolerance of ± 5 percent or ± 7 percent depending on the sensor part number. After the resistance of each sensor was measured, correct sensor wiring (continuity) was verified by connecting a jumper wire on the adapter cable, P/N 1B65095-1, and verifying that the sensor element for each transducer was shorted out to a resistance measurement of 5 ohms or less. All measurements for sensor element resistance and sensor wiring continuity were within tolerance as itemized in Test Data Table 4.1.19.1.

No discrepancies were documented as a result of this checkout. There was one revision recorded in the procedure deleting an adapter cable from the test equipment list, as it was not required for the checkout.

4.1.19.1 Test Data Table, Cryogenic Temperature Sensor Verification

Meas No	Sensor			Element Resistance (ohms)		Wiring Cont (5 ohms Max Limit)
	P/N	S/N	Ref Loc	Meas	Limits	Meas
CO 003	1B34473-1	306	403MT686	5310	5101-5867	1.2
CO 004	1B34473-501	297	403MT687	1554	1460-1612	1.3
CO 005	1A67863-503	908	405MT612	552	521-575	0.5
CO 008	1A67863-507	1050	403MT652	1560	1459-1611	1.2
CO 009	1A67863-535	775	403MT653	224	209-229	1.1
CO 015	1A67863-509	1084	410MT603	1560	1445-1597	1.8
CO 040	1A67862-505	563	406MT613	1530	1439-1589	1.1
CO 052	1A67862-513	303	408MT612	5500	4998-5750	1.6
CO 133	NA5-27215T5	11797	4013MTT17	1410	1309-1445	0.9
CO 134	NA5-27215T5	11623	4013MTT16	1400	1309-1445	0.7
CO 157	1A67863-537	1095	404MT685	5360	5101-5867	1.0
CO 159	1A67863-519	1118	424MT610	224	209-229	1.1
CO 161	1A67863-537	878	424MT733	5300	5101-5867	0.9
CO 163	1A67863-519	1117	424MT613	222	209-229	1.3
CO 207	1A67863-503	854	425MT600	555	515-569	1.5
CO 208	1A67863-503	851	405MT605	556	521-575	1.4
CO 254	1B37878-503	1298	409MT652	1540	1430-1580	1.0
CO 255	1B37878-503	658	409MT653	1573	1445-1597	0.7

4.1.20 Hydraulic System Setup and Operation (1B41005 B)

The purpose of this manual procedure was to ensure that the hydraulic system was correctly flushed, filled, bled, and maintained free of contamination during prefire test stand hydraulic system operation. The hydraulic system pressures and temperatures were checked for proper operational levels; the hydraulic system transducer circuits were tested for correct operation and response characteristics; and the engine operational clearance in the aft skirt was established.

The test was initiated on 17 May 1967, and was completed on 12 June 1967.

Proper operation of the auxiliary hydraulic pump, P/N 1A66241-509, S/N X454673, the main hydraulic actuator assemblies, P/N 1A66248-505-011, S/N's 56 and 57, and the accumulator/reservoir assembly, P/N 1B29319-519, S/N 16, were verified by this checkout.

Prior to operation of the stage hydraulic system, the Model DSV-4B-358 hydraulic pumping unit (HPU), P/N 1A67443-1, was checked to ensure that the hydraulic fluid met the cleanliness requirements. The HPU was connected to the stage via the pressure and return hoses, and hydraulic fluid was circulated through the stage system to ensure that the system was properly filled. Hydraulic fluid samples were taken and certified to be free of contamination.

The accumulator/reservoir was charged with gaseous nitrogen and the stage air bottles were charged to a pressure of 475 \pm 50 psig. The HPU was turned on and the hydraulic system pressure was increased to between 4000 psig and 4400 psig. The stage hydraulic system was then checked for leaks.

Upon completion of the leak check, the hydraulic system pressure was decreased to 1500 \pm 50 psig. The HPU bypass valve was opened, and the stage system pressure was then reduced to 1000 \pm 50 psig. The auxiliary hydraulic pump was, turned on and verified to be operating properly.

With the midstroke locks installed on the hydraulic actuators, the vernier scales were adjusted to indicate zero. The midstroke locks were removed

4.1.20 (Continued)

and the hydraulic system pressure was brought up to 3650 \pm 50 psig. The pitch and yaw vernier scales were read and the values were recorded in the Test Data Table. The HPU was turned off and the midstroke locks were re-installed.

The engine deflection clearance check was accomplished next. The gimbal control unit, P/N 1B50915, was installed and set up, the J-2 engine bellows protective covers were removed, and the platform extension, P/N 1B70629, was removed from the engine area. The J-2 engine restrainer and the hydraulic actuator midstroke locks were removed. After an inspection of the engine area for possible interference points, the HPU was turned on and the stage system pressure was brought up to 1000 psig. The pitch and yaw controls on the gimbal control unit were turned in the retract and extend directions, and it was verified that the pitch and yaw actuators responded to the commands. The pitch and yaw controls were centered, centering the actuators, and the HPU was turned off. The midstroke locks and the J-2 engine bellows protective covers were re-installed.

The verification and setup of the stage and test control center hydraulic system instrumentation was started by turning on the HPU and adjusting the pressure compensator until the system hydraulic pressure gauge indicated the desired pressure indications.

Preparations for the engine gimbal test were initiated by removing the midstroke locks and the J-2 engine bellows protective covers. The engine area was verified to be clear for gimbaling. The HPU was turned on and the system pressure was established at 3650 psig. Various signals of predetermined input values were applied to the pitch and yaw actuators by the computer and the resultant voltages were noted and recorded in the Test Data Table. Upon completion of the gimbal test, the HPU was turned off, the midstroke locks were re-installed, and the engine protective covers were re-installed.

The shutdown sequence of this checkout included a final air content test, which provided information necessary for system analysis by discharging a portion of the internal system fluid volume overboard. The volume discharged was determined to be a function of fluid thermal expansion under ground operating conditions (0°F to 160°F) at ambient temperature. The HPU was

4.1.20 (Continued)

turned on and the system pressure was increased to 3650 \pm 50 psig, the bypass valve was opened, and the HPU was turned off. Verification was made that the return pressure gauge indicated a minimum of 200 psig. The shutoff valve was cycled open and closed until the return pressure was reduced to 180 \pm 5 psig. An empty 100 milliliter graduate was placed under the drain port and by cycling the reservoir drain valve open and closed, the return pressure was decreased to 80 \pm 5 psig. The 11 milliliter volume of fluid bled off was less than the 16 milliliter maximum, as specified per design requirements. The reservoir oil temperature was measured at 84.7°F.

A check to determine the pressure decay of the stage air bottles was conducted next. The air bottles were verified to be charged to 470 psia, well within the 475 \pm 50 psia limits, and the pressure and range time were recorded. After a lapse of 24 hours, the bottle pressure was remeasured and recorded as 440 psia, well within the allowable limits.

It was noted in the Engineering Comments that revision 1 was performed without discrepancies and that the hydraulic system was configured the same as when the function generator failed, except that the actuator locks were installed. It was further noted that the function generator problem appeared to be the use of underrated fuses. Fuses of 1/8 amp were installed and the problem was eliminated. Notation was also made that the reservoir oil level switch problem was caused by an improperly configured cable, which was replaced; thus eliminating the problem.

There were no FARR's generated during the operation of this procedure; however, there were nine revisions written against the procedure for the following:

- a. One revision set up the HPU and performed a special test to troubleshoot the function generator, and attempt to determine when the fuses were overloaded.
- b. One revision reran a portion of the instrumentation support section to obtain the correct feedback voltages for the pitch and yaw actuator positions.
- c. One revision cycled the HPU to verify proper operation of the reservoir oil level low switch.
- d. One revision reran the shutdown portion of the procedure in order to secure the system after troubleshooting the function generator problems.

4.1.20 (Continued)

- e. One revision charged the hydraulic accumulator for use in the DDAS automatic procedure, and also charged the stage air bottle after it had been re-installed subsequent to serial number verification.
- f. One revision reperformed the engine clearance check subsequent to repositioning of a major hardwire cable.
- g. One revision deleted the requirement to record transducer serial numbers for measurement numbers C203, C204, D209, D575, D223, and D565, as they were not installed on the stage.
- h. One revision rechecked the engine restrainer side loads after the restrainer jam nut had been retightened to the proper torque value.
- i. One revision deleted the instrumentation setup for the hydraulic system automatic because it was not required for this stage.

4.1.20.1 Test Data Table, Hydraulic System Setup and Operation

<u>Test Description</u>	<u>Instrumentation</u>		<u>Actual (in.)</u>	<u>Requirement (in.)</u>
	<u>Name</u>	<u>Location</u>		
Actuator Position System Unpress.	Pitch Vernier	Pitch Actuator	0	0
	Yaw Vernier	Yaw Actuator	0	0
Actuator Position System Press.	Pitch Vernier	Pitch Actuator	0	Ref. Only
	Yaw Vernier	Yaw Actuator	0	Ref. Only

<u>Test Description</u>	<u>Instrumentation</u>		<u>Position</u>	<u>Voltage (vdc)</u>
	<u>Name</u>	<u>Location</u>		
Instrumentation Support	Pitch Position	Actuator TCC	0°	2.546
			+1°	2.207
			+2°	1.868
			+1°	2.208
			0°	2.541
	Pitch Position	Actuator TCC	0°	2.541
			-1°	2.874
			-2°	3.208
			-1°	2.877
			0°	2.544
	Yaw Position	Actuator TCC	0°	2.479
			+1°	2.840
			+2°	3.186
			+1°	2.831
			0°	2.484
	Yaw Position	Actuator TCC	0°	2.484
			-1°	2.139
			-2°	1.800
			-1°	2.149
			0°	2.496

4.1.21 Preliminary Propulsion Leak and Functional Check (1B71877 New)

This checkout procedure defined the operations required to certify the integrity of the stage propulsion system preliminary to static firing. All portions pertaining to SV stages and postfire operations were deleted.

The prefire test sequences performed during this checkout, initiated on 18 May 1967 and completed on 2 June 1967, consisted of the following system checkouts.

The calip pressure switch system leak checks, initiated and completed on 20 May 1967, performed a decay and leak check of the mainstage pressure switch diaphragms by pressurizing the system, through the J-2 customer connect panel, to 400 ± 10 psig, isolating the mainstage switches from the supply source, and monitoring the pressure decay for 15 minutes. The mainstage pressure switch checkout circuit was pressurized to 515 ± 10 psia and monitored for 5 minutes for pressure decay. Both checks were satisfactorily completed and the data appears in Test Data Table 4.1.21.1.

The stage integrity checks performed pickup and dropout tests on the control helium regulator discharge pressure switch, P/N 7851830-521, S/N 122, and the cold helium regulator backup pressure switch, P/N 7851830-517, S/N 111. During the pressure switch checks, audible leak checks were conducted on the cold and ambient helium systems. Audible leak checks were performed on the engine spheres by pressurizing the engine control bottle to 350 ± 50 psig, and the start tank to 250 ± 50 psig. Audible leak checks of the LOX and LH₂ tanks were accomplished with 5 psig of pressure indicated in the LOX tank, and 3 psig of pressure indicated in the LH₂ tank. After the conclusion of the above audible leak checks, stage integrity tests were initiated by pressurizing the control helium bottle to 3100 ± 100 psig, the start tank to 800 ± 25 psig, the cold helium spheres to 2275 ± 50 psia, and the engine control bottle to 2250 ± 50 psig. These pressures were held for 5 minutes. For a check of the LOX vent and relief valve, P/N 1A48312-505, S/N 14, and the LH₂ vent and relief valve, P/N 1A48257-509, S/N 47, the LOX and LH₂ tanks were pressurized to relief pressure and the vent valves were allowed to perform three relief cycles. The stage integrity checks were satisfactorily completed.

4.1.21 (Continued)

The ambient helium system leak and flow checks were:

- a. The stage purge system orifice flow verification and system leak checks of the LOX ullage sense line, LOX vent pilot chamber, LH₂ and LOX fill and drain microswitch housing, LH₂ chilldown shutoff valve microswitch purge and nonpropulsive vent valve duct.
- b. The pneumatic power control module, P/N 1A58345-513, S/N 1040, internal leakage check consisted of a control helium shutoff valve seat leakage check and a pneumatic power control module regulator lockup test.
- c. The control helium system leak and functional check consisted of an ambient helium system leak check and an actuation control module internal leakage check. This system was verified with three leakage conditions. One leak was repaired by retightening to the proper torque value, and the other two were determined to be within allowable limits by the cognizant propulsion engineer with the approval of NASA/MSFC resident quality control.
- d. The pneumatic control system lockup verified the control helium lockup with the valves in a normal position, and with the prevalues and chilldown shutoff valves closed, the vent valves open, and the LOX chilldown pump purge on.

The ambient helium system leak and flow checks were satisfactorily completed.

The engine start system leak and functional section performed a drying procedure of the start tank vent valve actuator, a seat leakage check of the start tank control solenoid valve, a reverse leakage check of the start tank fill check valve, and leakage checks of the GH₂ start system. Start bottle retention tests were conducted to measure the start bottle decay by calculating the pound-mass/hour loss. All tests of the engine start system were satisfactorily completed.

The thrust chamber leak checks performed a leak check of the ignition detector probe and the LOX dome purge line from the purge port on the LOX dome to the GSE purge check valve. The majority of the thrust chamber leak checks were performed during propulsion leak checks at the VCL per H&CO 1B70773.

The LOX pressurization system leak and functional check performed an internal leak and functional check of the LOX pressurization module, P/N 1B42290-503, S/N 0025, and leak checks of the LOX pressurization system and the cold helium system. Three leaks were observed during the cold helium system leak check,

4.1.21 (Continued)

between the main and auxiliary tunnel manifolds to the spheres. These leaks were associated with transducer plumbing and were repaired by replacing unions and retightening connections to the proper torque value. This section was rerun to reflect data for subsequent replacement of the LOX pressurization module, P/N 1B42290-503, S/N 0025, with P/N 1B42290-503, S/N 0037, per revision six.

The LOX tank and engine feed system leak checks performed internal leak checks of the engine feed system, which included the LOX pre valve, P/N 1A49968-509, S/N 101, the LOX chilldown shutoff valve, P/N 1A49965-521, S/N 0503, and the LOX chilldown return check valve, P/N 1A49964-501, S/N 259, and accomplished the engine LOX bleed valve and engine main oxidizer valve seat leakage checks. Also performed were the LOX tank and engine feed system leak checks; the LOX turbo pump torque checks; the leakage and purge flow checks of the LOX chilldown pump, P/N 1A49423-507-011, S/N 1761, the pump purge control module, P/N 1A58347-505, S/N 54, and the pump purge dump valve, P/N 1A67913-1, S/N 18; the LOX boil-off valve flow check; the LOX pre valve check; a seat leakage check of the LOX fill and drain valve, P/N 1A48240-505, S/N 0107; a seal leakage check at the main fill and replenish valve; and a LOX umbilical leak check. The LOX tank and engine feed systems were satisfactorily completed without leak conditions.

The LH₂ tank and engine feed system leak check performed internal leak checks of the engine feed system, which included the LH₂ chilldown return check valve, P/N 1A49964-1, S/N 270; accomplished the seat leakage checks at the LH₂ pre valve, P/N 1A49968-507, S/N 120, and LH₂ chilldown shutoff valve, P/N 1A49965-519, S/N 0302; and performed the seat leakage checks of the engine LH₂ bleed valve and main fuel valve. The LH₂ turbo pump torque checks, the LH₂ valves leakage check, a seat leakage check of the LH₂ fill and drain valve, P/N 1A48240-505, S/N 33, the LH₂ umbilical leak check, and the main fill and replenish valve seat leakage check were also performed. The LH₂ tank and engine feed system leak checks located two leaks at the inlet and outlet seals of the LH₂ vent and relief valve, P/N 1A48257-509, S/N 0047, which were repaired by seal replacement. The LH₂ tank and engine feed systems were satisfactorily completed.

4.1.21 (Continued)

The engine gas generator (GG) and exhaust system leak and flow checks performed engine seal leakage checks which included a reverse leakage check of the GG fuel purge check valve, an LH_2 and LOX turbine seal cavity bleed flow check, a start tank discharge valve gate seal leakage check, a leak check of the GG and exhaust system, and a GG LOX and LH_2 propellant valves seat leakage check. The engine GG and exhaust system leak and flow checks were satisfactorily completed.

The engine pneumatics leak and flow checks performed were:

- a. The engine solenoid energized leak checks, which included:
 1. A leak check of the helium control solenoid circuit and pneumatic package.
 2. LOX pump intermediate seal leakage checks in the pump direction and turbine direction; also a flow check on the cracking check valve overboard flow.
 3. A leak check from the main LOX valve sequence valve discharge.
- b. The pressure actuated purge system leak check, which performed a seat leakage check of the pressure actuated purge valve inlet and vent, and a pressure actuated purge circuit leak check.
- c. The engine control bottle fill system leak check, which performed a leak check of the engine control bottle and the fill line to the pneumatic package high pressure relief valve.
- d. The engine control bottle retention tests, which measured the control bottle pressure decay by calculating the pound-mass/hour loss.

All tests of the engine pneumatics system were satisfactorily completed.

The LOX and LH_2 vent system leak and flow checks performed leak and flow checks of the LOX and LH_2 vent systems, including a leak check of the nonpropulsive vent ducting and the LH_2 vent and relief ducting, and a directional vent valve flight position internal leak check. A ground vent system leak check included internal leakage checks of the LH_2 vent and relief valve, a directional vent ground position and actuator piston leak check, and ground vent system leak checks. The parts involved were the LOX tank vent and relief valve, P/N 1A48312-505, S/N 0014, the LOX tank relief valve, P/N 1A49590-515, S/N 547, the bi-directional vent valve, P/N 1A49988-1, S/N 0017, and the LH_2 tank vent and relief valve, P/N 1A49591-527, S/N 142. All tests of the LOX and LH_2 vent system

4.1.21 (Continued)

were satisfactorily completed, with two leak conditions noted at the LH_2 nondirectional vent adapter, P/N 1B60060-501, at the quadrant II and IV connections. Both leak conditions were recapped to IIS 196296 for corrective action.

Twelve leakage conditions were described in the leak check log, including three that were associated with GSE and facility interface systems. Seven leakage conditions were resolved by retightening to the proper torque value, or by the replacement of seals and unions with subsequent tightening to the proper torque value. Two leakage conditions, at the inlet fittings of the LOX pre valve, P/N 1A49968-509, S/N 101, and the LH_2 pre valve, P/N 1A49968-507, S/N 120, were determined to be within the 20 sccm allowable leakage per 1A49968.

One FARR was written during the operation of this test procedure.

FARR A251541 removed the LOX tank pressurization control module, P/N 1B42290-503, S/N 0025, and replaced it with another module, P/N 1B42290-503, S/N 0037. The reason for replacement was an excessive leakage of 2500 scim through the cold helium shutoff valve. The maximum allowable leakage was 375 scim.

Twenty-eight revisions were written against this test procedure, with one of these voided. The revisions incorporated were:

- a. Two revisions deleted sections of this procedure that were performed at the VCL during H&CO 1B70773.
- b. One revision instructed propulsion engineering to transcribe data from the VCL preliminary leak check procedure, H&CO 1B70773.
- c. One revision deleted one of the TV channel requirements during the stage integrity checkout due to inoperative equipment.
- d. One revision disabled the start tank vent valve to prevent dumping while personnel were working in the area.
- e. Two revisions reinstated steps that were deleted by revision 1 in "a" above. One was required as a result of replacing the LOX tank pressure control module, P/N 1B42290-503, S/N 0025, with P/N 1B42290-503, S/N 0037, and the others were required to rerun steps for systems troubleshooting.
- f. Six revisions were incorporated to leak check hardware which was replaced subsequent to the system leak checks.

4.1.21 (Continued)

- g. Eight revisions corrected and added procedural requirements that were in error or missing.
- h. One revision temporarily returned equipment to the precheckout configuration in order to perform the propulsion automatic procedure, H&CO 1B62762 E.
- i. One revision authorized the accomplishment of 10 engine sequences per the propulsion automatic procedure, H&CO 1B62762 E, to satisfy Rocketdyne Engineering Field Inspection Report 15.
- j. Three revisions added steps to acquire engineering data for the true engine pump purge pressure and the LH₂ chilldown fairing purge flow.
- k. One revision removed a test plate and blanking flange that were installed on the LOX pressurization line during the VCL checkout. The plate and flange should not be installed for the stage integrity checks.

There were no missing or substitute parts, and no modifications or EO's were pending that would void any portion of this test. All sections deleted from H&CO 1B70773 were performed during this test procedure, therefore, no subsequent testing was contemplated. The propulsion systems leak and functional checks were acceptable to Engineering, and this test procedure was signed off on 2 June 1967.

4.1.21.1 Test Data Table, Preliminary Leak and Functional Check

Engine Mainstage Pressure Switch Check

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Diaphragm Decay in 15 Minutes (psi)	2.0	10.0 max
Checkout Circuit Decay in 5 Minutes (psi)	1.0	5.0 max

Helium Pressure Switch Checks

<u>Function</u>	<u>Run 1</u>	<u>Run 2</u>	<u>Run 3</u>	<u>Limits</u>
<u>Control He Regulator Discharge PS</u>				
Pickup Pressure (psia)	588.0	586.0	586.0	600.0 ±21.0
Dropout Pressure (psia)	488.0	486.0	486.0	490.0 ±31.0
<u>Cold He Regulator Backup PS</u>				
Pickup Pressure (psia)	456.68	456.68	456.68	444.0 to 491.0
Dropout Pressure (psia)	356.68	356.68	356.68	329.0 to 376.0

4.1.21.1 (Continued)

Vent and Relief Valve Checks

<u>Function</u>	<u>Cycle 1</u>	<u>Cycle 2</u>	<u>Cycle 3</u>	<u>Limits</u>
LOX V&R Valve Relief Press (psia)	43.125	43.125	43.125	41.0 to 44.0
LH ₂ V&R Valve Relief Press (psia)	37.50	37.50	37.50	36.0 to 39.0

Purge System Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
<u>LOX Tank Purge Flows</u>		
Ullage Sense Line (scim)	250.0	423.0 \pm 245.0
Fill & Drain Valve Microswitch Housing (scim)	2.5	3.5 \pm 2.0
<u>LH₂ Tank Purge Flows</u>		
Fill & Drain Valve Microswitch Housing (scim)	1.8	3.5 \pm 2.0
Chiltdown Shutoff Valve Microswitch (scim)	6500.0	6500.0 \pm 2450.0
Nonpropulsive Vent Duct (scim)	200.0	432.0 \pm 245.0

Pneumatic Power Control Module Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Control He. Shutoff Valve Seat Leakage (scim)	0.0	10.0 max
Module Regulator Lockup Pressure (psig)	543.0	550.0 max

Control Helium Lockup Checks

<u>Valve Conditions</u>	<u>Lockup Pressure (psig)</u>	
	<u>Initial</u>	<u>After 30 Minutes</u>
Valves in Normal Position	544.0	537.0
Prevalves & C/D Shutoff Valves Closed, Vent Valves Open, LOX C/D Pump Purge On	540.0	500.0

Engine Start Tank Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Vent Control Solenoid Seat Leakage (scim)	0.0	10.0 max
Fill Check Valve Reverse Leakage (scim)	0.0	2.0 max
Tank Decay (Delta M = 0.0134 (lb-mass/hour)	0.00438	0.0066 max

LOX Tank Pressurization Control Module Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Cold He SOV Seat & Pilot Valve Leakage (scim)	0.0	375.0 max
Hot Gas Bypass Valve Seat & Pilot Valve Leak (scim)	13.5	1000.0 max
LOX Tank Helium Content (%)	99.0	75.0 min

4.1.21.1 (Continued)

LOX Tank and Engine Feed System Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Total Leakage, (Prevalve, C/D Shutoff Valve, and C/D Return Check Valve Reverse Leak) (scim)	48.0	*
C/D Return Check Valve Reverse Leakage (scim)	5.0	350.0 max
Prevalve & C/D Shutoff Valve Combined Seat Leak (scim)	43.0	*
Bleed Valve & C/D Return Check Valve Rev Leak (scim)	5.0	*
Bleed Valve Seat Leakage (scim)	0.0	*
Main Oxidizer Valve Seat Leakage (scim)	0.0	*
Oxidizer Pump Speed Pickup Seal Bleed (scim)	0.0	350.0 max
<u>LOX Turbo Pump</u>		
Primary Seal Leakage (scim)	4.0 to 4.5	350.0 max
Turbine Breakaway Torque (in.-lb)	108.0	1000.0 max
Turbine Running Torque (in.-lb)	81.0	200.0 max
<u>Chiltdown Pump Purge Module</u>		
Purge Shutoff Valve Solenoid Valve Leakage (scim)	0.0	1.0 max
Pump Purge Flow (scim)	40.0	33.0 to 49.0
<u>Chiltdown Pump Purge Dump Valve</u>		
Solenoid Valve Seat Leakage (scim)	0.0	0.0 max
<u>Chiltdown Pump Shaft Seal</u>		
Leakage, Tank Pressurized, Pump Purge On (scim)	3.7	50.0 max
Leakage in Pump Direction (LOX Tank Side) (scim)	0.0	*
Leakage in Tank Direction (Motor Container Side) (scim)	3.7	*
<u>Fill and Drain Valve</u>		
Seat Leakage (scim)	0.0	18.0 max

LH₂ Tank and Engine Feed System Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
C/D Return Check Valve Reverse Leakage (scim)	0.0	350.0 max
Prevalve & C/D Shutoff Valve Combined Seat Leak (scim)	0.0	150.0 max
Bleed Valve & C/D Return Check Valve Rev Leak (scim)	0.0	*
Bleed Valve Seat Leakage (scim)	0.0	300.0 max
Main Oxid & Fuel Valves Combined Seat Leak (scim)	0.0	*
Main Fuel Valve Seat Leakage (scim)	0.0	10.0 max

* Limits Not Specified

4.1.21.1 (Continued)

Function	Measurement	Limits
<u>LH₂ Turbo Pump</u>		
Speed Monitor Seal Bleed (scim)	0.0	0.0 max
Primary Seal Leakage (scim)	0.0	350.0 max
Turbine Seal Leakage (scim)	2050.0	3000.0 max
Turbine Breakaway Torque (in.-lb)	20.0	1000.0
Turbine Running Torque (in.-lb)	20.0	300.0
<u>LH₂ Prevalve</u>		
Shaft Seat Leakage, Open Position (scim)	0.0	10.0 max
Shaft Seat Leakage, Closed Position (scim)	0.0	10.0 max
<u>Fill and Drain Valve</u>		
Seat Leakage (scim)	0.0	18.0 max
<u>Main Fill and Replenish Valve</u>		
Combined Main Fill, Replenish, & F&D Seat Leak (scim)	0.0	*
Main Fill & Replenish Valve Seat Leakage (scim)	0.0	*
<u>Engine Gas Generator Checks</u>		
Function	Measurement	Limits
LOX Propellant Valve Seat Leakage (scim)	0.0	1.0 max
Combined LOX & LH ₂ Prop Valves Seat Leak (scim)	0.0	*
LH ₂ Propellant Valve Seat Leakage (scim)	0.0	*
<u>Engine Pneumatics Checks</u>		
Function	Measurement	Limits
<u>Engine Low Pressure Relief Valve</u>		
Seat Leakage (scim)	0.0	5.0 max
Pilot Bleed Leakage (scim)	0.5	10.0 max
<u>LOX Pump Intermediate Seal</u>		
Seal Leakage, Pump Direction (scim)	25.0	*
Seal Leakage, Turbine Direction (scim)	160.0	*
Seal Leakage, Total (scim)	185.0	850.0 max
Purge Check Valve Overboard Flow (scim)	3500.0	*
Purge Flow (scim)	3685.0	2600.0 to 7000.0

* Limits Not Specified

4.1.21.1 (Continued)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
<u>Pressure Actuated Purge Valve</u>		
Vent Seat Leakage (scim)	0.0	10.0 max
Inlet Seat Leakage (Scim)	0.0	10.0 max

Engine Control Bottle

Decay (lb-mass/hour)	0.0	0.036 max
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LOX and LH₂ Vent System Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
<u>LOX Relief Valve and Vent & Relief Valve</u>		
Combined Seat and Pilot Bleed Leakage (scim)	100.0	100.0 max
Combined Seat, Pilot Bleed, & Boost Piston Seal Leak (scim)	130.0	*
V&R Valve Boost Piston Seal Leakage (scim)	30.0	2420.0 max
<u>LH₂ Relief Valve and Vent & Relief Valve</u>		
Combined Seat and Pilot Bleed Leakage (scim)	10.5	150.0 max
Combined Seat, Pilot Bleed, & Boost Piston Seal Leak (scim)	270.0	*
V&R Valve Boost Piston Seal Leakage (scim)	259.5	1728.0 max
<u>Bi-Directional Vent Valve</u>		
Flight Position Seat Leakage (scim)	0.0	50.0 max
Ground Position Seat Leakage (scim)	0.0	50.0 max
Flight Position Actuator Piston Leakage (scim)	0.0	3.0 max
Ground Position Actuator Piston Leakage (scim)	0.0	3.0 max

* Limits Not Specified

4.1.22 Power Distribution System (1B59498 D)

Automatic checkout of the stage power distribution system during prefire operations verified the capability of the GSE to control power switching to and within the stage, and determined that initial static loads within the stage were not excessive. The procedure verified that particular stage relays were energized or de-energized, as required, and that bi-level talk-back indications were received at the GSE. Static loading of the various stage systems was determined by automatic measuring of the GSE supply current before and after turn-on of each system.

The power distribution system was successfully tested on 18 May 1967, and was accepted on 24 May 1967. The test was initiated by the performance of an automatic stage power setup, which established initial conditions, and then proceeded to a verification of the power supply and stage bus operation. This was accomplished by measurements of the stage component bus voltages, plus measurements of the forward and aft power supply current differentials with the power turned on and then turned off to each individual stage component bus. Measured values recorded during the test are shown in Test Data Table 4.1.22.1.

Starting with the engine control bus power turn-on, the current differential for the aft bus 1 power supply was measured. The engine control bus voltage, M6, was measured and determined to be within tolerance. The APS bus power was turned on, and again the current differential for the aft bus 1 power supply was measured. This operation was repeated for the engine ignition bus, measuring the aft bus 1 power supply current differential and the engine ignition bus voltage, M7. The engine ignition bus power and the APS bus power were then turned off and verified to be off.

The engine safety cutoff system (ESCS) power was turned on, and the aft bus 1 power supply current was measured. The component test power was turned on, and the aft bus 1 power supply current differential and the component test power voltage were measured. The component test power was turned off and verified by voltage measurements. The ESCS power was then turned off.

4.1.22 (Continued)

Checking the emergency detection systems (EDS), verification was made that the EDS 2 engine cutoff signal turned off the engine control bus power and prevented it from being turned back on, and also turned on the instrument unit (IU) range safety 1 EBW firing unit arm and engine cutoff signal. The engine control bus voltage was measured during this check, and again after the check with the bus turned back on. Verification was made that the EDS 1 engine cutoff signal turned on the nonprogrammed engine cutoff signal and the A0 multiplexer engine cutoff signal indication (K13). With the EDS 1 engine cutoff system turned off, the engine ready bypass on switch turned off the nonprogrammed engine cutoff signal and the A0 multiplexer engine cutoff signal indication.

The propellant point level sensor test was started by turning on the propellant level sensor power and measuring the resulting current differential for the forward bus 1 power supply. Next, each of the four LH₂ tank and four LOX tank point level sensors was verified to respond to simulated wet condition on commands within the allowable 300 milliseconds tolerance. A series of checks verified that a dry condition indication from any two point level sensors in either tank, obtained by simulated wet condition off commands, resulted in the required engine cutoff signal. For the dry condition of LOX tank point level sensors 1 and 2, the LOX depletion engine cutoff timer value was measured to determine the engine cutoff signal delay time. Each of the point level sensors was verified to respond to simulated wet condition off commands within the allowable 300 milliseconds tolerance. This completed the point level sensor testing.

Verification was made that the engine cutoff command turned on the A0 multiplexer engine cutoff signal indication (K13), the engine cutoff command indication (K140), and the engine cutoff. It was also verified that the nonprogrammed engine cutoff indication was not turned on by the engine cutoff command. With the engine cutoff command turned off, K140 was verified to be off while K13 and the engine cutoff remained on until turned off by the engine ready bypass.

The propellant utilization (PU) inverter and electronics power supply current was measured while power was momentarily turned on. The PCM RF assembly power was turned on, the RF group was verified to be on, the power supply differential current was measured, and the PCM RF transmitter output wattage was measured

4.1.22 (Continued)

through the AO and BO multiplexers. With the telemetry RF silence command turned on, the RF group was verified to be off, the PCM RF transmitter output wattage was measured through the AO multiplexer, and the switch selector output monitor voltage (K128) was measured with the PCM RF assembly power and the switch selector read commands 1 and 2 turned on. With the telemetry RF silence command turned off, the RF group was verified to be on, and the PCM RF transmitter output wattage was again measured through the AO multiplexer.

The rate gyro voltages were manually verified to be 28.0 ± 2.0 vdc with the gyro power turned on, and 0.0 ± 2.0 vdc with the gyro power turned off. Power was turned on to the environmental control group and the resultant forward power supply current differential was measured. The aft bus 2 power supply was verified to be within the 56.0 ± 4.0 vdc tolerance. The bus 4D141 56 volt supply was turned on, and the aft bus 2 voltage and power supply current were measured. The aft bus 2 power supply local sense indication was verified to be off, the LH₂ and LOX chilldown pump simulators were turned on, and the resultant aft bus 2 power supply current differentials were measured.

A series of automatic checks verified the operation of the external/internal transfer system for forward buses 1 and 2, and aft buses 1 and 2. The battery simulator voltages and the electrical support equipment load bank voltages were measured initially, then the power bus voltages were measured with the buses transferred to internal. The bus local sense indications were then verified to be off. The bus voltages were measured again with the buses transferred back to external, and the battery simulator voltages were measured with the simulators turned off. The aft bus 2 voltage was measured with the bus power supply turned off.

A series of checks verified that the switch selector register was operating properly, and that the instrument unit 28 vdc power supplies were on. Power was turned on to the range safety receivers after they were transferred to external power, and the resulting GSE power supply current differentials were measured. The range safety EBW firing units were verified to be on when transferred to external power and momentarily turned on. This completed the power distribution test.

4.1.22 (Continued)

Seventeen revisions were recorded in the procedure as follows:

- a. Eight revisions concerned correction of program errors.
- b. One revision deleted the requirement for automatic lineprinter print-out of the switch selector accumulated test cycles. This had not been incorporated into the automatic program. Accumulated switch selector cycles were recorded manually on a daily basis.
- c. One revision authorized a special electrical cable test setup for the required manual checkout of the rate gyro voltages, to substitute for the breakout box, P/N 1A66386-1, which was not available at the time of this checkout.
- d. One revision explained the out-of-tolerance forward 5 volt excitation module voltages measured during initial conditions scan. This problem was described previously in the stage power setup (1B59496), paragraph 4.1.15. Both procedures referred to FARR A251516, also discussed in paragraph 4.1.15.
- e. One revision corrected a program error for the tolerance on the APS bus power current. This error resulted in a malfunction indication prior to correction.
- f. One revision recorded the results of an investigation of a malfunction indication. The aft bus 1 local sense indication was not off as required due to a loose wire termination in the Model DSV-4B-133 signal distribution unit, P/N 1A59949-1. The wiring connection was corrected and the program was satisfactorily resumed.
- g. One revision authorized connection of the chilldown inverter simulators to perform the chilldown inverter measurements test.
- h. One revision deleted program requirements for the chilldown inverter measurements test, as the inverter load simulators were not modified for the stage prefire checkout.
- i. One revision authorized a manual test of the chilldown inverter measurements after modification of the load simulators. This was accomplished on 2 June 1967, and the measurements recorded are listed in the Test Data Table.
- j. One revision indicated that the LH₂ chilldown inverter frequencies measured for phase B to C and B1 to C1 were twice the normal expected values, because the frequency counter sometimes picked up the one-half frequency spikes in the peaks of the quasi-square wave generated by the LH₂ chilldown inverter, thereby giving a reading exactly twice the correct frequency.

There were no part shortages affecting the test, nor were any FARR's generated during this test.

4.1.22.1 Test Data Table, Power Distribution System

Function	Measurement	Limits
Engine Control Bus Current (amps)	0.100	2 \pm 2
Engine Control Bus Voltage (vdc)	28.245	28 \pm 2
APS Bus Current (amps)	0.100	2 \pm 2
Engine Ignition Bus Current (amps)	1.300	0 \pm 2
Engine Ignition Bus Voltage, On (vdc)	28.460	28 \pm 2
Engine Ignition Bus Voltage, Off (vdc)	0.062	0 \pm 2
Component Test Power Current (amps)	0.200	0 \pm 2
Component Test Power Voltage (vdc)	28.399	28 \pm 2
Engine Control Bus Voltage, EDS 2 On (vdc)	0.000	0 \pm 2
Engine Control Bus Voltage, EDS 2 Off (vdc)	28.214	28 \pm 2
Propellant Level Sensor Power Current (amps)	0.200	1 \pm 2
LOX Depletion Engine Cutoff Timer (sec)	0.549	0.560 \pm 0.025
PU Inverter & Electronics Power Current (amps)	4.301	3 \pm 2
PCM RF Assembly Power Current (amps)	5.300	4.5 \pm 3.0
PCM RF Transmitter Output Power, AO (watts)	19.005	10 min.
PCM RF Transmitter Output Power, BO (watts)	19.035	10 min.
PCM RF Transmitter Output Power, AO, TM RF Silence On (watts)	-0.089	0 \pm 2
Switch Selector Output Monitor, K128 (vdc)	2.169	2 \pm 1
Switch Selector Output Monitor, Umb (vdc)	1.999	2 \pm 1
PCM RF Transmitter Output Power, AO, TM RF Silence Off (watts)	19.095	10 min.
Environmental Control Group Power Current (amps)	0.301	0 \pm 2
Aft Bus 2 Current, Chilledown Pumps Off (amps)	0.000	5 max.
Aft Bus 2 Voltage (vdc)	55.999	56 \pm 4
Aft Bus 2 Current, LOX C/D Pump On (amps)	22.000	22 \pm 5
Aft Bus 2 Current, LH ₂ C/D Pump On (amps)	19.600	22 \pm 5
Forward Battery 1 Simulator Voltage (vdc)	28.44	28 \pm 2
Forward Battery 2 Simulator Voltage (vdc)	28.08	28 \pm 2
Aft Battery 1 Simulator Voltage (vdc)	28.44	28 \pm 2
Aft Battery 2 Simulator Voltage (vdc)	56.16	56 \pm 4
Bus 4D20 ESE Load Bank (vdc)	0.00	0 \pm 1
Bus 4D40 ESE Load Bank (vdc)	0.00	0 \pm 1
Bus 4D30 ESE Load Bank (vdc)	0.00	0 \pm 1
Bus 4D10 ESE Load Bank (vdc)	0.00	0 \pm 1
Forward Bus 1 Voltage, Internal (vdc)	28.36	28 \pm 2
Forward Bus 2 Voltage, Internal (vdc)	28.00	28 \pm 2
Aft Bus 1 Voltage, Internal (vdc)	26.96	28 \pm 2
Aft Bus 1 Voltage, External (vdc)	28.56	28 \pm 2
Aft Battery 1 Voltage (vdc)	0.08	0 \pm 1
Aft Bus 2 Voltage, Internal (vdc)	56.08	56 \pm 4
Aft Bus 2 Voltage, External (vdc)	56.08	56 \pm 4
Aft Battery 2 Voltage (vdc)	0.000	0 \pm 1
Forward Bus 1 Voltage, External (vdc)	28.36	28 \pm 2
Forward Battery 1 Voltage (vdc)	0.08	0 \pm 1
Forward Bus 2 Voltage, External (vdc)	28.12	28 \pm 2
Forward Battery 2 Voltage (vdc)	0.04	0 \pm 1
Aft Bus 2 Voltage, Pwr Supply Off (vdc)	0.08	0 \pm 1
Range Safety Receiver 1 External Power Current (amps)	1.001	0 \pm 2
Range Safety Receiver 2 External Power Current (amps)	0.499	0 \pm 2

4.1.22.1 (Continued)

Manual Chillydown Inverter Checks

<u>Function</u>	<u>Measurements</u>		<u>Limits</u>
	<u>LOX Inv.</u>	<u>LH₂ Inv.</u>	
Phase A B Voltage (vac)	40.73	41.05	*
Phase A C Voltage (vac)	40.99	41.21	*
Phase B C Voltage (vac)	42.17	42.00	*
Phase A1 B1 Voltage (vac)	40.67	41.03	*
Phase A1 C1 Voltage (vac)	40.87	41.12	*
Phase B1 C1 Voltage (vac)	42.10	41.92	*
Phase A B Frequency (Hz)	400.3	400.5	400 \pm 4
Phase A C Frequency (Hz)	400.1	400.4	400 \pm 4
Phase B C Frequency (Hz)	400.0	800.4**	400 \pm 4
Phase A1 B1 Frequency (Hz)	399.9	400.2	400 \pm 4
Phase A1 C1 Frequency (Hz)	399.8	400.1	400 \pm 4
Phase B1 C1 Frequency (Hz)	399.7	800.4**	400 \pm 4
Aft Bus 2 Voltage (vdc)	56.3	56.3	*
Aft Bus 2 Current (amps)	20.6	19.0	20 \pm 5

*Limits not specified

**Refer to revision discussion, item j.

4.1.23 Telemetry and Range Safety Antenna System Check (1B63147 D)

Removal of the PCM RF assembly, P/N 1B52721, S/N 30, for rework from the -509 to the -521 configuration, and subsequent reinstallation, required checkout of the PCM RF assembly per this procedure. The test was conducted and accepted on 18 May 1967. System hardware installed at the time of this test included:

<u>Part Name</u>	<u>Reference Location</u>	<u>P/N</u>	<u>S/N</u>
PCM RF Assembly	411A64A200	1B52721-521	30
Bi-Directional Coupler	411A64A204	1A69214-503	158
Coaxial Switch	411A64A202	1A69213-1	67
Power Divider	411A64A201	1A69215-501	37
Telemetry Antennas	411E200 & E201	1A69206-501	52 & 53
Reflected Power Detector	411MT744	1A74776-501	2-0171
Forward Power Detector	411MT728	1A74776-503	2-0258
Dummy Load	411A64A203	1A84057-1	389
Directional Power Divider	411A97A56	1B38999-1	24
Hybrid Power Divider	411A97A34	1A74778-501	44
Range Safety Antennas	411E56 & E57	1A69207-501	35 & 36

Stage power was turned on for the PCM transmitter test. A dummy load, P/N 1A84057-1, S/N 389, was connected to the output of the transmitter, and power was turned on to the PCM RF assembly. After allowing 3 minutes for transmitter

4.1.23 (Continued)

warmup, a 5 vdc input signal was applied and the output frequency was measured at 258.538 MHz. The frequency measurement was then repeated after reversing the polarity of the 5 vdc input. This repeat measurement was recorded at 258.465 MHz. The PCM transmitter center frequency was calculated by averaging the two measured frequencies, and the carrier deviation was calculated as one-half of the differential between the two measured frequencies. The resultant center frequency of 258.501 MHz and carrier deviation of 36.5 kHz were within the allowable limits of 258.500 ± 0.026 MHz and 36.0 ± 3.0 kHz, respectively. No other checks were required to requalify the PCM RF assembly and it was accepted for use.

No problems were noted during this test and no FARR's were initiated. One revision was recorded in the procedure deleting all tests except the PCM transmitter center frequency and carrier deviation checks.

4.1.24 Level Sensor and Control Unit Calibration (1B63148 C)

This manual procedure provided the checks to verify that the control units associated with the LOX and LH₂ liquid level sensors, point level sensors, fast fill sensors, and overfill sensors, were adjusted for an operating point within the limits of the capacitance change caused by a simulated wet condition of the sensors.

The procedure was initially conducted on 19 May 1967; however, it was reissued on 12 June 1967 to recalibrate the LOX point level 4 sensor and control unit. The control unit adjustment screw seal was discovered to be missing. This seal is normally installed after control unit adjustment. Breaking the seal necessitated recalibration of the control unit.

During the calibration test, the point level sensor manual checkout assembly, P/N 1B50928-1, was connected between each control unit and its associated level sensor, and the precision capacitor, General Radio type 1422CD, was connected in parallel with each sensor. This provided capacitance changes to each control unit to simulate wet conditions for calibration, and to determine the control unit operating points. A voltmeter was then connected to the appropriate checkout assembly test points to measure the control unit output voltage.

4.1.24 (Continued)

To establish the operating point for each of the sensor control units under test, the precision capacitor was set to an appropriate capacitance to simulate a wet condition for the associated sensor. The required settings for the precision capacitor were 0.7 ± 0.01 picofarads for all LH_2 sensors except the LH_2 overfill sensor, which required 1.10 ± 0.02 picofarads, and 1.50 ± 0.02 picofarads for all LOX sensors except the LOX overfill sensor, which required 2.10 ± 0.02 picofarads. After turning on power to the individual control unit, the control unit potentiometer (R1) was adjusted until activation of the control unit relay was indicated by a change in output voltage from 0 ± 1 vdc to 28 ± 2 vdc. The capacitance of the precision capacitor was then decreased to obtain an output voltage of 0 ± 1 vdc, indicating relay deactivation, and again increased to obtain an output voltage of 28 ± 2 vdc, indicating relay reactivation. The deactivation and reactivation capacitance values were recorded as noted in Test Data Table 4.1.24.1.

A series of checks then verified the operation of the control unit output relay test function. With the associated sensor disconnected, each control unit output relay was verified to be deactivated under both normal and test conditions. With the sensors reconnected, the output relay for each control unit was verified to be deactivated under normal conditions and activated under test conditions.

No problems were encountered during the test and no FARR's were initiated. One revision recorded in the procedure deleted all sections of the reissue on 12 June 1967, except those portions involving the recalibration of LOX point level sensor 4, as previously noted. As shown in the Test Data Table, the LOX overfill measurements were out-of-tolerance, due to an operator error in establishing the control unit operating point. This procedure was to be reaccomplished following stage storage to establish the correct operating point prior to stage shipment.

Function	Sensor P/N 1A68710			Control Unit P/N 1A68710			Deact. Cap. (pf)		React. Cap. (pf)	
	Ref. Loc.	Dash No.	S/N	Ref. Loc.	Dash No.	S/N	Meas.	Min.	Meas.	Max.
<u>LH₂ Tank</u>	<u>408</u>			<u>411</u>						
Liq. Level L1	MT634	-1	D64	A61A217	-509	E21	0.6666	0.5	0.6668	0.9
Liq. Level L2	MT635	-1	D66	A61A219	-509	E40	0.6787	0.5	0.6807	0.9
Pt. Level 1	A2C1	-507	D22	A92A25	-509	D58	0.6962	0.5	0.6981	0.9
Pt. Level 2	A2C2	-507	D31	A92A26	-509	D59	0.6960	0.5	0.6967	0.9
Pt. Level 3	A2C3	-507	D32	A92A27	-509	D29	0.6666	0.5	0.6683	0.9
Pt. Level 4	A2C4	-507	D45	A61A201	-509	D89	0.6695	0.5	0.6707	0.9
Fastfill	A2C5	-1	D69	A92A43	-509	D57	0.6820	0.5	0.6826	0.9
Overfill	***	***	***	A92A24	-509	D56	1.067	0.9	1.068	1.3
 <u>LOX Tank</u>	 <u>406</u>			 <u>404</u>						
Liq. Level L4	MT632	-1	D53	A63A221	-511	D74	1.435	1.3	1.436	1.7
Liq. Level L5	MT633	-1	D56	A63A206	-511	D73	1.439	1.3	1.442	1.7
Pt. Level 1	A2C1	-1	D44	A72A1	-511	D130	1.453	1.3	1.459	1.7
Pt. Level 2	A2C2	-1	D49	A72A2	-511	E23	1.480	1.3	1.481	1.7
Pt. Level 3	A2C3	-1	D60	A72A3	-511	D41	1.482	1.3	1.483	1.7
Pt. Level 4	A2C4	-1	D68	A63A239	-511.1	D105	1.454*	1.3	1.458*	1.7
Fastfill	A2C5	-1	D50	A72A5	-511	D88	1.448	1.3	1.452	1.7
Overfill	**	**	**	A72A4	-511	D91	1.478@	1.9	1.480@	2.3

* Measurements per 12 June 1967 Recalibration

** Part of LOX Mass Probe 406A1, P/N 1A48430-509, S/N D6

*** Part of LH₂ Mass Probe 408A1, P/N 1A48431-505, S/N D6

@ Out-of-tolerance measurements due to operator error (Refer to comment, previous page)

4.1.24.1 Test Data Table, Level Sensor and Control Unit Calibration

4.1.25 Common Bulkhead Vacuum System (1B49286 G)

The purpose of this manual checkout, initiated on 19 May 1967, was to ensure that the common bulkhead, P/N 1A39309-501, was free of leakage conditions and acceptable for propellant loading and static acceptance firing. The checkout included the following activities.

The test stand vacuum system was isolated from the stage system, and the test stand system was setup for checkout. The vacuum pump was operated for 10 minutes, shut off, and after a 15 minute delay, the vacuum system pressure was recorded. Periodically, at intervals of 1 hour, the pressure was monitored for a pressure rise. No increase in pressure was noted over an 8 hour span.

The test stand system was reconnected to the stage and preparations for a 96-hour pumpdown of the common bulkhead were made. The evacuation supply was set to evacuate the bulkhead, the vacuum supply and vacuum pump were turned off, and the purge supply and sample supply were verified to be closed. Verification was made that measurement D545, the bulkhead pressure transducer, P/N 1B40242-501, was installed and electrically connected to the monitoring strip charts in the test control center.

It was verified that the common bulkhead quick-disconnect assembly, P/N 1B41065, was properly installed and engaged. Two sample bottles, P/N 1B71532-1, were installed at positions 1 and 2 on the sample bottle rack and sealed into place. The vacuum supply switch was turned on. After a time lapse of 10 minutes, the evacuation supply switch was set to evacuate the bottles, and sample supply switch number 1 was opened. After 5 minutes, sample supply switch number 1 was closed, the evacuation supply switch was set to sample the bulkhead, and sample supply switch number 1 was reopened. After 1 minute, sample supply switch number 1 was closed, and the evacuation supply switch was set to evacuate the bulkhead. Bulkhead pressure was monitored every hour for 6 hours, with no pressure rise noted. Upon completion of the 6-hour check, the evacuation supply switch was set to evacuate the bottles, and sample supply switch number 2 was opened. After a lapse of 5 minutes, sample supply switch number 2 was momentarily closed while setting the evacuation supply switch to sample the bulkhead. The sample supply switch, number 2, was then closed 1 minute later, and the

4.1.25 (Continued)

evacuation supply switch was set to evacuate the bulkhead. The sample bottles, number 1 and 2, were removed from the sample bottle rack and shipped to Material Research and Production Methods (MR&PM) Engineering for analysis.

After 96 hours of vacuum pumpdown, the vacuum supply switch was turned off, and the evacuation supply switch was set to evacuate the bottles. Then the 48-hour bulkhead decay check was started. The indicated bulkhead pressure at the start was recorded as 0.5 psia. No decay in bulkhead pressure was noted. During the decay check, setup was made for the argon purge test. A bottle of 100 percent pure argon was connected to the bulkhead GN₂ supply line. The bulkhead GN₂ purge hand valve was opened, the evacuation supply switch was set to evacuate the bulkhead, and the purge supply regulator was set to 2.5 psig. The argon purge was run until ambient bulkhead pressure was obtained. After purge completion the argon bottle was removed and the bulkhead vacuum system was secured.

The bulkhead leak check was accomplished next. Bulkhead pressure was determined to be 15.25 psia. The LOX tank was pressurized to 30 \pm 1 psia, and the fuel tank to 25 \pm 1 psia. This pressure was maintained for 12 hours, while the bulkhead pressure was monitored. No increase in bulkhead pressure was noted, indicating that the bulkhead was free from leakage. The propellant tanks were vented to ambient and this checkout was certified as acceptable on 8 June 1967.

FARR A251439 was initiated during the bulkhead 96-hour vacuum pumpdown when inspection revealed the bulkhead top fitting, P/N 1B29959-1, to be plugged with 1P20057 sealant. The fitting was removed, cleaned out, and reinstalled after ensuring that the bulkhead mating ports were clear. There were no other significant problems and no other FARR's were initiated during this test.

Seven revisions were recorded in the procedure.

- a. Two revisions authorized disassembly and inspection of common bulkhead fittings for obstructions due to indications of blockage during initial attempts for the bulkhead 96-hour vacuum pumpdown. Refer to the previous discussion of FARR A251439.

4.1.25 (Continued)

- b. Two revisions provided instructions for securing the common bulkhead argon purge for weekend and holiday shutdowns.
- c. One revision deleted the 24-hour requirement for securing the argon purge of the common bulkhead because the ambient bulkhead pressure objective had been obtained.
- d. One revision deleted the recording of "stop" data in Table III, based on verification of data in previous steps of the procedure.
- e. One revision corrected a procedure error.

4.1.26 Propellant Utilization System Calibration (1B63373 C)

This manual procedure provided instruction for the operation and calibration of the propellant utilization (PU) system prior to automatic checkout. For calibration purposes, the propellant utilization test set (PUT/S), P/N 1A68014-1, was used to provide varying capacitance inputs to the propellant utilization electronics assembly (PUEA), simulating the LOX and LH₂ mass probe outputs under varying propellant load conditions. The items involved in this test were the static inverter-converter, P/N 1A66212-505, S/N 00011; the propellant utilization electronics assembly, P/N 1A59358-527, S/N 029; the LOX mass probe, P/N 1A48430-509-001, S/N D6; and the LH₂ mass probe, P/N 1A48431-505-008-009, S/N D6.

Prior to the initiation of this procedure, the LH₂ mass probe, P/N 1A48431-505, S/N D1, was damaged while it was being reworked to SEO 1A48431-505-009. FARR A251499 rejected S/N D1 and replaced it with S/N D6.

Accomplished and certified on 23 May 1967, the calibration checkout was accepted by Engineering. Megohm resistance measurements were made on the LH₂ and LOX mass probes using a 50 vdc megohmmeter. All resistance measurements were greater than the 1000 megohm minimum requirement. The output voltage and operating frequency of the static inverter-converter were measured. The resulting values, as shown in Test Data Table 4.1.26.1, were within the specified range. The PUEA LH₂ bridge was calibrated for the empty condition by nulling the PUT/S ratiometer, at a reading of 0.02000, and then nulling the PUEA R2 potentiometer. The PUEA LOX bridge was calibrated for the empty condition by nulling the PUT/S ratiometer, at a reading of 0.02004, and then nulling the PUEA R1 potentiometer. The PUEA LH₂ and LOX bridges were then calibrated for the full condition by setting the PUT/S ratiometer to 0.82105 and nulling the LH₂ bridge PUEA R4

4.1.26 (Continued)

potentiometer and the LOX bridge PUEA R3 potentiometer. Data acquisition was verified by establishing simulated empty and full conditions; and determining the PUT/S ratiometer settings required to null the PUEA LH₂ and LOX bridges. The values obtained, as shown in the Test Data Table, were within the required limits. Bridge slew checks were conducted by establishing simulated 1/3 and 2/3 slew conditions and determining the PUT/S ratiometer settings required to null the PUEA LH₂ and LOX bridges for each case.

The reference mixture ratio (RMR) calibration was then accomplished. The first step consisted of determining the difference between the LOX empty and LH₂ empty ratiometer readings and multiplying this by 98.4 vdc, the result being designated as reference voltage V1 (1.960 vdc). Simulated empty conditions were set up and PUEA residual empty bias potentiometer R6 was nulled.

Simulated full conditions were then established with the PUT/S C1 capacitor (LH₂) set to 183.51 picofarads, and the PUT/S C2 capacitor (LOX) set to 115.99 picofarads. The PUEA residual full bias potentiometer R5 was then set to null the RMR bias voltage. The LH₂ and LOX bridge linearity checks were then accomplished by adjusting the PUT/S capacitors, C1 for the LH₂ test and C2 for the LOX test, to specific values, and determining that the PUT/S ratiometer settings were within design specifications. For hardwire loading checks, the LH₂ and LOX bridge outputs were checked under simulated full conditions, and were found to be within the tolerance of 23.52 \pm 2 vdc.

Engineering comments indicate that all parts were installed and there were no IUM's in use at the start of this checkout. Two revisions were written during this procedure:

- a. Revision one reran a portion of the checkout after replacement of the static inverter-converter, S/N 115. Reference FARR A251546.
- b. The second revision added a 50 vdc megohmmeter and a 10 inch-pound torque wrench to the list of non-end item equipment, as they were required during the test.

FARR A251546 documented a failure of the static inverter-converter output. No modification or rework was scheduled that would invalidate the results of this procedure and the propellant utilization system was accepted for use.

4.1.26.1 Test Data Table, Propellant Utilization System Calibration

Static Inverter-Converter Output Checks

<u>Function</u>	<u>Measurements</u>	<u>Limits</u>
5 vdc Output (vdc)	5.0	4.5 to 5.1
21.0 vdc Output (vdc)	21.62	20 to 22.5
28.0 vdc Output (vdc)	28.028	24 to 30
V/P Excitation Output (vdc)	51.17	48 to 52.5
115 vrms Monitor (vdc)	2.716	2.28 to 3.18
117 vdc Output (vdc)	122.0	115 to 122.5
TP2 Reading (vdc)	21.76	20 to 22.5
Frequency (Hz)	399	394 to 406

Data Acquisition

<u>Function</u>	<u>PUT/S Ratiometer</u>
LH ₂ Empty	0.01393
LOX Empty	0.03385
LH ₂ Full	0.82106
LOX Full	0.82116

Bridge Slew Checks

<u>Function</u>	<u>PUT/S Ratiometer</u>
LH ₂ 1/3 Slew	0.29292
LH ₂ 2/3 Slew	0.57843
LOX 1/3 Slew	0.27487
LOX 2/3 Slew	0.55209

LH₂ Bridge Linearity Check

<u>PUT/S C1</u>	<u>PUT/S Ratiometer</u>	<u>Limits</u>
50 pf	0.21963	0.21751 to 0.22079
100 pf	0.44445	0.44292 to 0.44456
150 pf	0.66951	0.66834 to 0.67162
183.51 pf	0.82128	0.81941 to 0.82269

LOX Bridge Linearity Check

<u>PUT/S C2</u>	<u>PUT/S Ratiometer</u>	<u>Limits</u>
20 pf	0.14469	0.14339 to 0.14667
50 pf	0.34113	0.33965 to 0.34293
70 pf	0.47151	0.47050 to 0.47378
100 pf	0.66810	0.66677 to 0.67005

4.1.27 Propellant Utilization System (1B59504 D)

This automatic checkout verified the capability of the propellant utilization (PU) system to determine and control the engine propellant flow mixture ratio in a manner that ensured simultaneous propellant depletion. The test also verified the capability of the PU system to provide propellant level information for controlling the fill and topping valves during LOX and LH₂ loading operations. The automatic checkout system (ACS) was utilized during testing to function PU system components and to monitor responses. This test involved all components of the stage PU system, including:

<u>Part Name</u>	<u>Ref. Location</u>	<u>P/N</u>	<u>S/N</u>
Propellant Utilization			
Electronics Assy	411A92A6	1A59358-525	029
Static Inverter-Converter	411A92A7	1A66212-505	00011
LOX Mass Probe	406A1	1A48430-509-001	D6
LH ₂ Mass Probe	408A1	1A48431-505-009	D6
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511.1	D91
LOX Fastfill Sensor	406A2C5	1A68710-1	D50
LOX Fastfill Control Unit	404A72A5	1A68710-511.1	D88
LH ₂ Overfill Sensor	(Part of LH ₂ Mass Probe)		
LH ₂ Overfill Control Unit	411A92A24	1A68710-509	D56
LH ₂ Fastfill Sensor	408A2C5	1A68710-1	D69
LH ₂ Fastfill Control Unit	411A92A43	1A68710-509	D57

Initial conditions for the test were established on 24 May 1967, and the ratio values, obtained from the manual PU system calibration procedure, H&CO 1B63373, were loaded into the computer. From these ratio values, nominal test values were computed for LOX and LH₂ coarse mass voltages, fine mass voltages, and loading voltages. After an evaluation of the computer printout, a test of the PU system power was made. Power was applied to the PU inverter-converter, and the forward bus 2 voltage was measured. After a programmed delay of 15 minutes, to allow the inverter-converter to stabilize, the output voltage and frequency were measured and determined to be within specified limits. An additional delay of 30 minutes was required for the PU oven temperature to stabilize. Verification was made that the oven temperature was within the tolerance range. The data for this test appears in Test Data Table 4.1.27.1.

4.1.27 (Continued)

The servo bridge balance and ratio valve null tests were conducted next. The error voltages, as well as the LOX and LH₂ coarse and fine voltages, were measured and determined to be within design specifications and tolerance limits.

The PU loading test was accomplished next. The GSE power supply voltage was measured as 28.879 vdc. The LOX and LH₂ loading potentiometer sense voltages were measured, and the LOX and LH₂ loading potentiometer signal voltages were measured. The LOX and LH₂ 1/3 checkout relay commands were turned on, and the LOX and LH₂ loading potentiometer signal voltages were again measured. The checkout relay commands were turned off, and the LOX and LH₂ loading potentiometer sense voltages were again measured.

The servo balance bridge gain test was conducted next, starting with a measurement of the error signal voltage and the ratio valve position in degrees. The LOX and LH₂ coarse and fine mass voltages were measured initially, and were remeasured with the 1/3 and 2/3 checkout relay commands turned on. In reverse order the voltages were measured as the 2/3 and 1/3 checkout relay commands were turned off. All measurements were within the required limits as determined by the ACS.

The next test checked operation of the overfill and fastfill sensors in the LOX and LH₂ tanks. This test was accomplished by verification that the proper indications were registered under ambient (dry) and under simulated wet conditions of the sensors.

For a PU valve movement test, 50 second plus valve slew checks and 50 second minus valve slew checks were conducted. The preslew ratio valve position voltage and the system test valve position signal were measured before each of the slew checks was started. During each slew, the ratio valve position voltage was measured through the AO telemetry multiplexer at 3, 5, 8, 20, and 50 seconds after the slew started, to determine the change in the position voltage from the preslew measurement. As shown in the Test Data Table, all of the measurements were within the required limits.

4.1.27 (Continued)

The PU activate test was conducted next, with the measurements made through both the A0 and B0 multiplexer circuits. The ratio valve position was measured, the LOX bridge 1/3 checkout relay command was turned on, and the LOX coarse mass voltage was measured. The ratio valve position was remeasured with the PU activate switch turned on, and again with it turned off. The LOX bridge 1/3 checkout relay command was turned off and all voltages were remeasured. These steps were then repeated using the LH₂ bridge 1/3 checkout relay, and measuring the LH₂ coarse mass voltage.

Engineering comments indicated that no interim use material items were installed and there were no part shortages at the start of this test.

Two revisions were written against the procedure for the following:

- a. One revision was written to accept the low voltage indications from the forward 1 and 2 5 vdc excitation modules. The voltage indications were 4.97 vdc and 4.96 vdc for forward modules 1 and 2, respectively. The voltage indications should have been 5 \pm 0.003 vdc. The 30 millivolt line drop resulted from sharing the return line with the signal conditioning rack.
- b. One revision, to the PU valve movement test, changed the table of acceptable limits for the plus 1 volt valve slew test to be plus degrees, and for the minus 1 volt valve slew test to be minus degrees. This was necessary to correct a programming error due to the table revision.

No FARR's were written as a result of this test, and the PU system was accepted for use on 24 May 1967. There were no planned modifications that would invalidate the results of this test.

4.1.27.1 Test Data Table, Propellant Utilization System

Loaded Ratio Values from H&CO 1B63373

LOX Empty Ratio	0.014	LOX 1/3 Bridge Slew Ratio	0.275
LH ₂ Empty Ratio	0.000	LOX 2/3 Bridge Slew Ratio	0.552
LOX Wiper Ratio	0.034	LH ₂ 1/3 Bridge Slew Ratio	0.293
LH ₂ Wiper Ratio	0.014	LH ₂ 2/3 Bridge Slew Ratio	0.578
Residual Bias Empty Volts	1.96		

4.1.27.1 (Continued)

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.068	LH ₂ Empty	0.000
LOX 1/3 Mass	1.377	LH ₂ 1/3 Mass	1.465
LOX 2/3 Mass	2.759	LH ₂ 2/3 Mass	2.891

Computed Fine Mass Voltages (vdc)

LOX Empty	3.340	LH ₂ Empty	1.367
LOX 1/3 Mass	1.011	LH ₂ 1/3 Mass	0.708
LOX 2/3 Mass	3.931	LH ₂ 2/3 Mass	1.398

Computed Loading Voltages (vdc)

LOX Empty	0.383	LH ₂ Empty	0.000
LOX 1/3 Coarse Mass	7.711	LH ₂ 1/3 Coarse Mass	8.203

PU System Power Test

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Forward Bus 2 Voltage (vdc)	28.76	28.0 +2.0
Inverter-Converter 115 vrms (vac)	114.830	115.0 +3.4
Inverter-Converter 21 vdc (vdc)	21.601	21.25 +1.25
Inverter-Converter 5 vdc (vdc)	4.996	4.8 +0.3
Inverter-Converter Frequency (Hz)	399.844	400.0 +6.0
Internal Temperature (°F)	76.762	75.0 +35.0

Bridge Balance and Ratio Valve Null Test

<u>Function</u>	<u>Meas.</u>	<u>AO Multiplexer</u>	<u>BO Multiplexer</u>
Error Signal Voltage (vdc)	2.098		
Ratio Valve Position (deg)	1.067		
LOX Coarse Mass Voltage (vdc)		0.068	0.073
LOX Fine Mass Voltage (vdc)		3.335	3.325
LH ₂ Coarse Mass Voltage (vdc)		0.000	0.000
LH ₂ Fine Mass Voltage (vdc)		1.313	1.304

PU Loading Test

<u>Function</u>	<u>Measurement</u>
GSE Power Supply Voltage (vdc)	28.879
LOX Loading Sense Voltage (vdc)	28.879
LH ₂ Loading Sense Voltage (vdc)	28.839
LOX Loading Signal Voltage (vdc)	0.383
LH ₂ Loading Signal Voltage (vdc)	0.000

4.1.27.1 (Continued)

<u>Function</u>	<u>Measurement</u>
<u>1/3 Checkout Relay Commands On</u>	
LOX Loading Signal Voltage (vdc)	7.547
LH ₂ Loading Signal Voltage (vdc)	8.012

1/3 Checkout Relay Commands Off

LOX Loading Signal Voltage (vdc)	0.039
LH ₂ Loading Signal Voltage (vdc)	0.000

Servo Balance Bridge Gain Test

<u>Function</u>	<u>Meas.</u>	<u>AO Multiplexer</u>	<u>BO Multiplexer</u>
Error Signal Voltage (vdc)	2.098		
Ratio Valve Position (deg)	1.199		
LOX Coarse Mass Voltage (vdc)		0.073	0.073
LOX Fine Mass Voltage (vdc)		3.315	3.320
LH ₂ Coarse Mass Voltage (vdc)		0.010	0.005
LH ₂ Fine Mass Voltage (vdc)		1.313	1.309

1/3 Checkout Relay Commands On

Ratio Valve Position (deg)	1.594		
LOX Coarse Mass Voltage (vdc)		1.377	1.377
LOX Fine Mass Voltage (vdc)		1.021	1.025
LH ₂ Coarse Mass Voltage (vdc)		1.475	1.470
LH ₂ Fine Mass Voltage (vdc)		0.801	0.801

2/3 Checkout Relay Commands On

Ratio Valve Position (deg)	2.055		
LOX Coarse Mass Voltage (vdc)		2.778	2.778
LOX Fine Mass Voltage (vdc)		3.711	3.682
LH ₂ Coarse Mass Voltage (vdc)		2.910	2.915
LH ₂ Fine Mass Voltage (vdc)		1.055	1.050

2/3 Checkout Relay Commands Off

Ratio Valve Position (deg)	1.660		
LOX Coarse Mass Voltage (vdc)		1.382	1.377
LOX Fine Mass Voltage (vdc)		1.025	1.021
LH ₂ Coarse Mass Voltage (vdc)		1.470	1.470
LH ₂ Fine Mass Voltage (vdc)		0.796	0.791

1/3 Checkout Relay Commands Off

Error Signal Voltage (vdc)	2.098
Ratio Valve Position (deg)	1.199

4.1.27.1 (Continued)

<u>Function</u>	<u>A0 Multiplexer</u>	<u>B0 Multiplexer</u>
LOX Coarse Mass Voltage (vdc)	0.054	0.063
LOX Fine Mass Voltage (vdc)	3.335	3.335
LH ₂ Coarse Mass Voltage (vdc)	0.010	0.000
LH ₂ Fine Mass Voltage (vdc)	1.313	1.318

PU Valve Movement Test

50 Second Plus Valve Slew

<u>Slew</u>	<u>Time</u>	<u>Degrees</u>	<u>Limits (deg)</u>
+1	T +3	V1 = 4.146	1.92 to 6.00
+1	T +5	V2 = 5.198	2.51 to 6.99
+1	T +8	V3 = 5.659	2.81 to 6.99
+1	T +20	V4 = 5.923	4.94 to 6.99
+1	T +50	V5 = 5.988	4.94 to 6.99

50 Second Minus Valve Slew

<u>Slew</u>	<u>Time</u>	<u>Degrees</u>	<u>Limits (deg)</u>
-1	T +3	V1 = -3.749	-1.92 to -6.00
-1	T +5	V2 = -4.670	-2.51 to -6.99
-1	T +8	V3 = -5.131	-2.81 to -6.99
-1	T +20	V4 = -5.394	-4.94 to -6.99
-1	T +50	V5 = -5.394	-4.94 to -6.99

PU Activate Test

<u>Function</u>	<u>A0 Multiplexer</u>	<u>B0 Multiplexer</u>
PU Ratio Valve Position (deg)	1.133	1.133
<u>LOX 1/3 Checkout Relay On</u>		
LOX Coarse Mass Voltage (vdc)	1.382	1.382
<u>PU System On</u>		
PU Ratio Valve Position (deg)	32.320	32.386
<u>PU System Off</u>		
PU Ratio Valve Position (deg)	1.463	1.528
<u>LOX 1/3 Checkout Relay Off</u>		
LOX Coarse Mass Voltage (vdc)	0.078	0.068
PU Ratio Valve Position (deg)	1.330	1.265
<u>LH₂ 1/3 Checkout Relay On</u>		
LH ₂ Coarse Mass Voltage (vdc)	1.465	1.470
<u>PU System On</u>		
PU Ratio Valve Position (vdc)	-25.841	-25.776
<u>PU System Off</u>		
PU Ratio Valve Position (deg)	1.40	1.40
<u>LH₂ 1/3 Checkout Relay Off</u>		
LH ₂ Coarse Mass Voltage (vdc)	0.000	0.000
PU Ratio Valve Position (deg)	1.999	1.265

4.1.28 Propulsion System Test (1B62762 E)

This automatic procedure performed the integrated electro-mechanical functional tests of the stage propulsion system. The procedure was divided into five sections, each of which was performed separately. The first section of the test checked the pressure switches for activation, deactivation, and proper control functions. The second section checked the pneumatic control system for functional capability and valve operation. The third section verified the operation of the LOX tank pressurization system, and the fourth section verified the operation of the LH₂ tank pressurization system. The fifth section of the test was a four part check of the J-2 engine. The first segment of the J-2 engine checkout tested the spark ignition systems for the J-2 engine thrust chamber and gas generator, the second segment functionally checked the engine cutoff logic and delay timers, the third segment checked the J-2 engine valve sequencing with control helium pressurization, and the final segment was a combined automatic check of the J-2 engine system operation.

Initiated on 24 May 1967, the procedure was completed on 27 May 1967, and was accepted on 5 June 1967. The sections of the procedure are presented in order. Measurements made during the procedure are shown in Test Data Table 4.1.28.1.

Section 1, the pressure switch test, was completed on the first attempt on 25 May 1967. The control helium sphere dump valve, the control helium supply shutoff valve, the cold helium dump valve, the cold helium supply shutoff valve, the LOX chilldown pump purge control and dump valves, and the engine pump purge control valve were actuated to ensure proper operation. Then the cold helium regulator backup pressure switch and the control helium regulator backup pressure switch were checked for pickup and dropout pressures after pressurizing the GSE stage 4 regulator to 650 \pm 25 psia. These pressures are listed in the Test Data Table. All pressure switch tests were repeated twice.

Section 2, the pneumatic control system test, was completed on the first attempt on 25 May 1967. The control helium sphere was pressurized to 700 \pm 50 psia and the control helium regulator discharge pressure was set at 515 \pm 50 psia. Then the opening and closing times for the LOX and LH₂ vent valves, fill and drain valves, prevalues, and chilldown shutoff valves were measured. The time for

4.1.28 (Continued)

the LH₂ directional control vent valve to go to the flight position and the actuation time for it to go to the ground position were also measured. These measurements are recorded in the Test Data Table. The last test performed in Section 2 was a check of the switch selector for each of the above valves.

The next test was the LOX tank pressurization system test, Section 3, performed satisfactorily on 25 May 1967, on the first attempt. The GSE stage 7 regulator was pressurized to 50 \pm 5 psia, and the line and dome pressures were measured. Pressure was applied to the system, and the pressure switch manifold pressurization time and the LOX tank ground fill pressure switch pickup pressure were measured. The cold helium supply shutoff valve was opened, and it was verified that the flight control pressure switch would close the cold helium shutoff valve. Then it was verified that the LOX tank flight pressure on command would open the cold helium shutoff valve.

It was next verified that the coast period on command closed the cold helium shutoff valve, and that the coast period off command opened the cold helium shutoff valve. The LOX tank flight pressure system on command was turned off, then the stage 7 regulator bleed valve was opened, the pressure switch manifold depressurization time was measured, and the LOX ground fill pressure switch dropout pressure was measured. The ground fill pressure switch test was repeated twice.

To verify the proper operation of the cold helium heat exchanger bypass valve, the cold helium supply shutoff valve was opened, and the LOX pressurization module helium gas pressure and the cold helium control valve inlet pressure were measured while the bypass valve was opened and closed.

The cold helium spheres were then pressurized to 950 psia for the cold helium sphere blowdown and pressure regulator test. A series of simultaneous sphere pressure and regulator discharge pressure measurements were recorded, while flowing the cold helium bottle supply through the pressure regulator of the LOX pressurization control module, until a sphere pressure of 617.67 psia was measured. For simplicity, only three sets of the measurements recorded during the cold helium blowdown test are shown in the Test Data Table.

4.1.28 (Continued)

Section 4, the fuel tank pressurization system test, was also conducted successfully on 25 May 1967. After opening the LH₂ tank pressurization module, the inlet gas pressure was measured before and after closing the step pressure valve with the LH₂ first burn relay on command.

The GSE stage 6 helium regulator was then pressurized to 50 \pm 5 psia to conduct the LH₂ tank pressure switch tests. After pressure was applied, the pickup pressures were measured and recorded for the LH₂ tank flight control, the LH₂ ground fill overpressure, and the LH₂ orbital coast vent high pressure switches. It was then verified that the LH₂ first burn bypass control valve was closed by the pressure switch pickup. The LH₂ tank pressurization module inlet gas pressure was also measured before and after the first burn bypass control valve closure. The pressure switch system was then vented, and measurements were made of the LH₂ pressure switch dropout pressures that resulted in opening the LH₂ first burn bypass control valve. Opening the step pressure valve by turning off the LH₂ first burn relay completed the LH₂ switch tests and the LH₂ pressurization module valve functional check. As shown in the Test Data Table, the LH₂ pressure switch tests were repeated twice.

Section 5, the J-2 engine test, was successfully demonstrated on the first attempt on 27 May 1967. The first portion of the J-2 engine system test verified that the emergency detection system (EDS) engine cutoff command 1, with the propellant tanks at ambient pressure, resulted in an engine cutoff indication and a nonprogrammed engine cutoff indication. With the EDS engine cutoff command locked on the telemetry K140 relay, the EDS 1 engine cutoff command was turned off, the switch selector engine ready bypass command was turned on, the EDS 2 engine cutoff command was turned on, and it was verified that the EDS 2 engine cutoff command did not result in nonprogrammed stage cutoff. It was then verified that the engine control bus power on command was disabled by the EDS 2 on command.

Next, it was verified that the LOX and LH₂ prevalues and chilldown shutoff valves were held closed by the ground command. The component test power, the engine control bus power, and the engine ignition bus power were turned on and the

4.1.28 (Continued)

respective voltages were verified to be within tolerance, in preparation for the engine cutoff checks. The thrust chamber and gas generator spark systems 1 and 2, were checked and verified to be operative. The start tank was pressurized and its pressure was measured preparatory to the start tank vent valve check. The start tank vent valve was opened, closed, and re-opened. The resulting start tank pressure differentials were measured and determined to be within the prescribed limits for proper vent valve operation.

For the engine cutoff checks, the component test power and the switch selector engine cutoff command were turned on, and it was verified that the engine cutoff indication was on. The engine cutoff command was turned off, and it was verified that the engine cutoff lock was reset. The engine ignition bus power was then turned off and it was verified that the engine ready indication was off.

For a test of the engine ignition cutoff and the LH₂ injection temperature detector bypass, a series of steps verified that the start tank discharge control indication and the engine start indication were on when the switch selector engine start command, the aft separate simulation 1 and 2, and the switch selector LH₂ injection temperature detector bypass were all turned on. The switch selector engine start command was turned off, and it was verified that the engine cutoff indication was on within the predetermined time limit. The engine ignition timer delay time was measured, and the aft separate simulation 1 and 2 were turned off.

For the mainstage cutoff test, an engine ignition and cutoff sequence was accomplished, and the operating times of the engine ignition delay timer, the helium delay timer, the spark de-energizer timer, and the start discharge timer, were measured. The ignition detection indication was verified to be on when the engine cutoff was on.

For the check of the mainstage OK pressure switches 1 and 2, the GSE stage 2 and stage 4 helium regulators were pressurized to 650 \pm 50 psia. Pressure was applied to the mainstage OK pressure switch 1, and the pickup pressure was measured. The mainstage OK pressure switch 1 depressurized indication, and the engine thrust OK 1 and 2 indications, were verified to be off. The engine

4.1.28 (Continued)

start sequence was accomplished and the ignition detected indication was verified to be on. Pressure from the stage 2 regulator was applied to the mainstage OK pressure switch 2, and the pickup pressure was measured. The pressure to switch 1 was reduced, and the dropout pressure was measured. The engine thrust OK 1 and 2 indications were verified to still be off, and it was verified that the dropout of switch 1 did not cause engine cutoff while switch 2 was picked up. The pressure to switch 2 was reduced, and the dropout pressure was measured. It was verified that the engine thrust OK 1 and 2 indications were on, and that the dropout of both mainstage OK pressure switches had caused engine cutoff. The pressure switch check was repeated twice, while measurements were made of the switch pickup and dropout pressures.

For the helium control solenoid valves check, the control helium supply sphere was pressurized to 1352 psia. The helium control solenoid valve was opened, and the engine regulator output pressure was measured at 329.9 psia. Valve positions were then verified by hardwire and telemetry. The LH₂ and LOX bleed valves were verified to be closed. The ignition phase control solenoid valve was opened, and verification was made that the engine ASI oxidizer valve and the engine main fuel valve were open. The start tank solenoid valve was opened and the start tank discharge valve was verified to be open. The mainstage control solenoid valve was opened and it was verified that the gas generator valve was open, that the LOX turbine bypass valve was closed, and that the engine main LOX valve was open.

The start tank solenoid valve was closed, and the start tank discharge valve was verified to be closed. The mainstage control solenoid valve was closed and it was verified that the engine main LOX valve and the gas generator valve were closed, and that the LOX turbine bypass valve was open. The ignition phase control solenoid valve was closed, and it was verified that the engine ASI oxidizer valve and the engine main fuel valve were closed. The helium control solenoid valve was closed and the LH₂ and LOX bleed valves were verified to be open.

4.1.28 (Continued)

For the final engine sequence check, the engine ignition bus power was turned on, the entire engine system was verified to be ready for the check, and the component test power was turned on. The engine sequence check was an automatic repetition of previous parts of the engine system test. The necessary commands were given to cause engine start and engine cutoff, and the system responses to the commands were verified to be within the predetermined limits. Various operating times were measured during the sequence to verify the proper operation of the system component items. The recorded measurements are listed in the Test Data Table.

Nineteen revisions were recorded in the procedure as follows:

- a. One revision explained the out-of-tolerance forward 5 volt excitation module voltages measured during the initial conditions scan. This problem is described previously in the stage power setup, paragraph 4.1.15. Refer to FARR A251516.
- b. One revision authorized a setup modification to connect the pressure checkout line directly into the LOX tank pressure switches, to avoid pressurizing the LOX tank transducers during the pressure switch tests.
- c. Four revisions corrected program errors.
- d. One revision authorized the installation of an orifice at valve A-9536 in the GSE test stand pneumatic control console A, to reduce the flow rate for the propulsion system test.
- e. One revision explained that a "no closed indication" for valve A-9378, during the GSE pneumatic console initial conditions scan, resulted because the valve was removed for repairs. This revision authorized proceeding without the GSE valve because it was not required for the propulsion system test.
- f. One revision accepted a malfunction statement of "no open indication" for the ambient helium sphere dump valve because insufficient program time was allowed for the sphere dump rate. The acceptance was based on the intent to modify the TRD to allow more time in the program.
- g. One revision attributed a malfunction statement of "no closed indication" for the LOX chilldown pump purge dump valve to low stage control sphere pressure, which had decayed due to a previous nonprogrammed halt. The low sphere pressure resulted in a slow LOX chilldown pump motor container purge pressure rise rate, which was not within the program limits.

4.1.28 (Continued)

- h. One revision noted that type statements requiring manual pressurization of the control sphere and the cold helium bottle spheres occurred because the bottle pressures fell below 250 psia, as a result of the dump and shutoff valve routines. The revision indicated that these were not malfunction statements, but rather instructions from the computer to establish initial conditions for the pressure switch tests.
- i. One revision attributed the lack of a closed indication for the GSE LOX auxiliary tank pressurization valve to an operator error during the initial conditions scan for section 3. The valve was cycled closed and the program was resumed.
- j. One revision noted that a "no closed indication" for the GSE helium heat exchanger 3 supply valve resulted from a valve talkback switch malfunction. The valve was removed and replaced.
- k. One revision attributed an out-of-tolerance pressure switch system venting to an undersize orifice in the GSE pressurization circuit. The restrictor selected for system venting was too small to give good pressurization rates within the program time limits.
- l. One revision explained that the engine main LOX valve malfunction, "no closed indication", during the J-2 engine shutdown sequence, was within the allowable 90 milliseconds limit after the engine cutoff signal. The oscillograph records indicated that the valve delay time, after the engine cutoff signal, was actually 32 milliseconds, well within the 90 milliseconds program limit. The DDAS function is updated every 83 milliseconds, which permits the possibility of valve time indication errors.
- m. Three revisions attributed SIM interrupts, during the J-2 engine sequence testing, to program errors, which were corrected by program revisions.
- n. One revision authorized deletion of the requirements for the line-printer to record cycles accumulated by the switch selector. The existing practice provided manual recording of switch selector cycles on a daily basis.

There were no discrepancies during this test that resulted in FARR documentation. Engineering Comments noted that the ASI ignition detection probe, P/N 500750, required for the static acceptance firing, was not installed during propulsion system testing, and that the interim use ASI ignition detection probe, P/N NA5-27298-T2, S/N 108, was installed for the prefire checkout only.

Another notation in the Engineering Comments stated that the main fuel valve closed travel time and gas generator valve LOX poppet start time out-of-tolerance conditions resulted from the inability of the computer to accurately time events during a scan routine.

There were no other discrepancies noted and the test was accepted on 29 May 1967.

4.1.28.1 Test Data Table, Propulsion System Test

Section 1 - Pressure Switch Tests

<u>Function</u>	<u>Test 1</u>	<u>Test 2</u>	<u>Test 3</u>	<u>Limit</u>
Cold He PS Pickup Pressure (psia)	458.1	458.7	458.1	467.5 \pm 23.5
Cold He PS Dropout Pressure (psia)	355.8	355.2	355.2	352.5 \pm 23.5
Control He PS Pickup Pressure (psia)	599.5	598.9	598.9	600 \pm 21
Control He PS Dropout Pressure (psia)	499.6	499.0	499.0	490 \pm 31

Section 2 - Pneumatic Control System Test

<u>Function</u>	<u>Measurement</u>	<u>Limit</u>
Control He Sphere Pressure (psia)	723.53	700 \pm 50
Control He Reg Discharge Press (psia)	552.45	515 \pm 50

<u>Function</u>	<u>Operating Times (sec)</u>					
	<u>Open</u>	<u>Tot. Open</u>	<u>Close</u>	<u>Tot. Close</u>	<u>Boost</u>	<u>Tot. Boost</u>
LH ₂ Vent Valve	0.013	0.074	0.170	0.398	0.078	0.226
LOX Vent Valve	0.015	0.078	0.117	0.346	0.062	0.223
LOX Fill & Drain Valve	0.132	0.238	0.682	2.083	0.412	0.921
LH ₂ Fill & Drain Valve	0.156	0.287	0.888	2.344	0.461	0.981
LOX Prevalve	1.418	2.149	0.250	0.389	-	-
LH ₂ Prevalve	1.319	2.089	0.269	0.416	-	-
LOX CD Shutoff Valve	0.198	0.963	0.026	0.128	-	-
LH ₂ CD Shutoff Valve	0.294	1.002	0.038	0.143	-	-

<u>Function</u>	<u>Flt Pos</u>	<u>Tot. Flt Pos</u>	<u>Grnd Pos</u>	<u>Tot. Grnd Pos</u>
LH ₂ Direction Vent Valve	0.050	0.150	0.763	1.221

Section 3 - LOX Tank Pressurization System Test

Pressure Switch Check

<u>Function</u>	<u>Test 1</u>	<u>Test 2</u>	<u>Test 3</u>	<u>Limit</u>
Manifold Press Time (sec)	39.325	35.635	34.261	*
Manifold Depress Time (sec)	46.679	46.621	46.502	*
Ground Fill PS Pickup (psia)	40.02	40.02	40.02	41 max
Ground Fill PS Dropout (psia)	37.56	37.56	37.61	36.5 min
Ground Fill PS Deadband (psi)	2.46	2.46	2.40	0.5 min

Heat Exchanger Bypass Valve Check

<u>Function</u>	<u>Bypass Closed</u>	<u>Bypass Open</u>
LOX Press Module He Gas Press D105, (psia)	345.19	149.89
Cold He Control Valve Inlet Press, D225 (psia)	317.37	90.97

*Limits not specified

4.1.28.1 (Continued)

Section 3 - LOX Tank Pressurization System Test (Continued)

Cold Helium Regulator Test

<u>Function</u>	<u>Reg Disch D105 Press (psia)</u>	<u>He Sphere D016 Press (psia)</u>
Pressurize Cold He Bottle	422.66	942.28
First Measurement	416.65	885.00
Mid Measurement	412.84	755.16
Final Measurement	395.92	625.31

Section 4 - LH₂ Tank Pressurization System Test

Pressure Switch Check

<u>Function</u>	<u>Test 1</u>	<u>Test 2</u>	<u>Test 3</u>	<u>Limit</u>
Flight Control PS Pickup (psia)	29.311	29.311	29.258	30.0 max
Flight Control PS Dropout (psia)	27.226	27.121	27.173	26.5 min
Flight Control PS Deadband (psi)	2.08	2.19	2.08	0.5 min
Grnd Fill Overpress PS Pickup (psia)	33.534	33.534	33.430	34.5 max
Grnd Fill Overpress PS Dropout (psia)	31.030	31.030	31.030	30.8 min
Grnd Fill Overpress PS Deadband (psi)	2.50	2.50	2.40	0.5 min
Orb Coast Vent Hi PS Pickup (psia)	35.256	35.202	35.256	35.0 ± 1.0
Orb Coast Vent Hi PS Dropout (psia)	31.969	31.865	31.969	30.5 min
Orb Coast Vent Hi PS Deadband (psi)	3.287	3.337	3.287	0.5 min

LH₂ Pressure Module Valve Functional Check

<u>Valve Status :</u>	<u>Module Inlet, D104 Press (psia)</u>	<u>Limit (psia)</u>
Valves Open (A)	112.11	*
Step Press Valve Closed	201.57	(A +60) +40, -0
Step Press Valve Closed (B)**	201.574	*
First Burn Bypass Valve Closed	345.594	B +100 min

Section 5 - J-2 Engine System Test

Engine Delay Timer Check

<u>Function</u>	<u>Measurement</u>	<u>Limit</u>
Engine Ignition Timer Delay (sec)	0.432	0.45 ± 0.03
Helium Delay Timer (sec)	1.009	1.0 ± 0.11
Sparks De-Energize Timer (sec)	3.286	3.3 ± 0.20
Start Tank Discharge Timer (sec)	1.005	1.00 ± 0.03

*Limits not specified

**Repeat Measurement Prior to Bypass Valve Closure

4.1.28.1 (Continued)

Section 5 - J-2 Engine System Test (Continued)

Mainstage OK Pressure Switches Check

<u>Function</u>	<u>Test 1</u>	<u>Test 2</u>	<u>Test 3</u>	<u>Limit</u>
Mainstage OK PS 1 Pickup (A) (psia)	526.08	527.33	526.69	515 \pm 36
Mainstage OK PS 1 Dropout (psia)	458.51	457.89	458.51	(A-62.5) \pm 43.5
Mainstage OK PS 2 Pickup (B) (psia)	529.42	530.03	528.80	515 \pm 36
Mainstage OK PS 2 Dropout (psia)	464.92	466.17	466.17	(B-62.5) \pm 43.5

Engine Sequence Check

<u>Function</u>	<u>Start Time</u> (sec)	<u>Oper Time</u> (sec)	<u>Total Time</u> (sec)
Ignition Phase Solenoid Talkback	-	0.021	-
Control He Solenoid Talkback	-	0.016	-
ASI LOX Valve Open	-	0.047	-
LOX Bleed Valve Closed	-	0.088	-
LH ₂ Bleed Valve Closed	-	0.065	-
Main LH ₂ Valve Open	0.081	0.058	0.139
Start Tank Discharge Timer	-	1.002	-
Start Tank Disch Valve Open	0.104	0.119	0.223
Mainstage Control Solenoid Energ	-	1.452	-
Ignition Phase Timer	-	0.450	-
Start Tank Disch Control Sol Off	-	0.006	-
Main LOX Valve Open	0.322	1.954	2.276
Start Tank Disch Valve Closed	0.188	0.114	0.303
Gas Gen Valve Open	0.078	0.108	0.187
LOX Turbine Bypass Valve Close	0.279	0.251	0.530
Spark System Off Timer	-	3.292	-
Ignition Phase Control Sol Off	-	0.007	-
Mainstage Control Solenoid Off	-	0.015	-
ASI LOX Valve Closed	0.038	-	-
Main LH ₂ Valve Closed	0.117	0.164	0.281
Main LOX Valve Closed	***	***	0.148
Gas Generator Valve Closed	0.125	0.082	0.207
Control He Sol De-Energ Timer	-	1.014	-
LOX Turbine Bypass Valve Open	0.297	0.496	0.793
LOX Bleed Valve Open	8.888	-	-
LH ₂ Bleed Valve Open	9.950	-	-

***No Data Printout, Refer to revision 1.

4.1.29 Signal Conditioning Setup (1B63149 C)

This procedure calibrated the stage 5 volt and 20 volt excitation modules, and calibrated any items of the stage signal conditioning equipment that were found to be out-of-tolerance during testing. The signal conditioning equipment consisted of those items required to convert transducer low level or ac signals to the 0 to 5 vdc form used by the telemetry system, and included dc amplifiers, temperature bridges, frequency to dc converters, and expanded scale voltage monitors.

This procedure was initiated on 24 May 1967, and was certified as completed on 1 June 1967. The items calibrated during this test are noted in Test Data Table 4.1.29.1.

The input voltage to each 5 volt excitation module was verified to be 28 ± 0.1 vdc, and each module was adjusted to obtain a 5 vdc output of 5.0 ± 0.005 vdc. The final values measured, as shown in the Test Data Table, were all within the prescribed limits.

No part shortages were recorded that affected this test. No problems were encountered during the test and no FARR's were written. One revision was made to the procedure to delete all sections of the test that were not accomplished, because no other out-of-tolerance conditions occurred during stage systems checkouts which required the use of this procedure.

4.1.29.1 Test Data Table, Signal Conditioning Setup

5 Volt Excitation Module - P/N 1A77310-503

<u>Reference Location</u>	<u>S/N</u>	<u>Output (vdc)</u>	<u>Limits (vdc)</u>
411A99A33	099	5.001	5.000 ± 0.005
404A75A7	0101	5.003	5.000 ± 0.005
411A98A2	0100	5.001	5.000 ± 0.005

4.1.30 Digital Data Acquisition System (1B59500 D)

The digital data acquisition system (DDAS) automatic test provided operational status verification of data channels on the stage, except certain data channels that were tested during specific system tests. The outputs of these

4.1.30 (Continued)

channels were checked by the D924A computer and found to be within the specified tolerances. The proper operation of all DDAS signal conditioning units and associated amplifiers, the command calibration channel decoder assembly, and the transmitter output and the antenna system were also checked by the computer.

Components of the DDAS installed during this test included: The PCM/DDAS assembly, P/N 1A74049-511, S/N 05; the CP1-BO time division multiplexer, P/N 1B62513-531, S/N 017; the DP1-BO time division multiplexer, P/N 1B62513-533, S/N 03; the remote digital submultiplexer (RDSM), P/N 1B52894-1, S/N 09; the remote analog submultiplexer (RASM), P/N 1B54062-503, S/N 012; and the PCM RF assembly, P/N 1B52721-521, S/N 030.

Prefire DDAS automatic testing was successfully accomplished on 29 May 1967, and was accepted on 5 June 1967.

All channels having a calibration capability were compared one at a time to the tolerance limits by the computer. Transducer analog outputs were signal conditioned and fed to the multiplexers. The multiplexer unit input channels were electronically sampled at a given rate, then these samples were fed into the digital data acquisition assembly (DDAA). The DDAA received these output samples through a time share gate and converted them to 10 bit binary coded words. The DDAA output was fed into the ground station and the PCM RF transmitter by coaxial cable. The ground station output was fed into the computer for tolerance verification. High mode and low mode calibration command signals were provided by the remote automatic calibration systems (RACS) which used binary coded ground commands to a central calibration command decoder assembly in the stage. These signals were fed into the signal conditioning modules to provide channel operation verification in the DDAS. Channels without RACS capability and spare channels were tested by comparing their end item outputs at ambient conditions to tolerance limits. Ambient conditions were defined as 70°F at 14.7 psia or, for bi-level parameters, the normal state of valves or switches during the performance of this test. All channel outputs were measured and printed out.

4.1.30 (Continued)

Special channel tests at 400 Hz, 100 Hz, and 1500 Hz were performed, in the order given, following completion of the DP1-B0 multiplexer tests. The 400 Hz test checked the static inverter-converter, the LOX circulation pump flow rate, and the LH₂ circulation pump flow rate. LOX and LH₂ flowmeter tests at 100 Hz followed the 400 Hz test. The LOX and LH₂ pump speeds were checked using the 1500 Hz test input. The indications displayed during the special channel tests were as expected.

There were no discrepancies or malfunctions resulting in FARR documentation. All problems encountered were resolved in the revisions recorded in the procedure. There were no part shortages affecting the test. An interim use pressure transducer for measurement number D576, P/N 1A72913-539, S/N 240-1, was installed for checkout and static firing, after which the flight configuration transducer, P/N 1B40242-509, S/N 509-22, replaced it.

Fourteen revisions were recorded in the procedure as follows:

- a. One revision listed FILADD entries required to add calibration values to the program for the J-2 engine transducers.
- b. Two revisions listed program changes required due to the removal of the heaters from the battery simulators.
- c. Four revisions corrected program errors.
- d. One revision attributed an out-of-tolerance indication for measurement D043, the GN₂ accumulator pressure transducer, to low GN₂ accumulator temperature. The expected pressure value in the program was based on an accumulator temperature 20 degrees warmer. The recorded pressure was well within an adjusted expected value based on 20 degrees lower temperature.
- e. One revision attributed out-of-tolerance measurements for the common bulkhead internal pressure transducers, measurements D237 and D545, to insufficient time allowed for bulkhead internal pressure stabilization prior to this test. D545 measured above ambient and D237 below the ambient pressure requirement. Subsequent to this test, sufficient time was allowed for stabilization, and D545 and D237 were verified to be at ambient pressure.
- f. One revision explained the cause of an out-of-tolerance pitch actuator piston position, measurement G001. The actuator center locks had not been installed, resulting in the engine being off center. The engine was subsequently centered and measurement G001 was verified to be within tolerance.
- g. One revision attributed a malfunction statement "main LOX valve closed indication K121, not on" to electrical disconnection of the valve during the test. The valve was subsequently connected and K121 was verified to be on.

4.1.30 (Continued)

- h. One revision explained that the cause of the out-of-tolerance indication for the fuel tank inlet pressure transducer (D054) was a program error resulting from erroneous transducer calibration curve input. D054 was calculated to be within tolerance based on the indicated output voltage at ambient pressure and using the actual transducer curve.
- i. One revision indicated that the SIM channel 067 interrupts received during the test resulted from cycling engine safety cutoff system power.
- j. One revision concerned a GSE malfunction, Channel 6 lockout, unrelated to stage checkout.

4.1.31 Integrated System Test (1B59514 E)

This automatic checkout verified the design integrity and operational capability of the S-IVB stage and facility systems which were functioned during propellant loading and static acceptance firing.

The automatic and manual test sequences performed during this checkout were initiated on 3 June 1967, and were certified as complete and acceptable on 6 June 1967.

The stage power setup established a known condition by a matrix reset, and systematically applied power to the vehicle buses and systems required for operation of the test. This section was satisfactorily completed and the test proceeded into the next section without any out-of-tolerance conditions noted.

The GSE valve functional checkout established an ambient condition in the pneumatic console subsequent to a bleed-down of all regulators, and then reset the regulators to predetermined values. All console and sled valves used in propellant loading and static acceptance firing were cycled, and the heat exchanger was functioned. There were two malfunctions during these operations. One, indicating that the GN_2 crossover supply did not close, was attributed to the crossover valve being slow to operate. The other, a SIM interrupt, indicated that the LH_2 pre valve did not operate. The pre valve was operated during a SIM disable, but not when the SIM was enabled, therefore no valve operation was seen by the SIM. This section was satisfactorily completed and the next section was entered.

4.1.31 (Continued)

The DDAS section of the test was accomplished next, with the PCM transmitter operated open loop. The telemetry 5 step calibration, the high and low RACS, and special calibrations of flows, speeds, and frequencies were commanded to provide verification of all calibration techniques. The parameters on the CP1 and DP1 multiplexers and remote analog and digital submultiplexers, which were required for loading or firing, were verified by receipt of proper response through open loop PCM transmissions. At the conclusion of DDAS, the output was again received by the 600 Hz VCO. During the CP1 section of the test, thirty-seven functions were verified to be off while sixteen were on. The DP1 section indicated nine functions were off while thirteen were on. There were 15 channel malfunctions associated with this section. D016 and D177 through D180 failed during the CP1 multiplexer test, and D016, D054, and D177 through D180 failed during the DP1 multiplexer test. The strain gauge pressure transducers D016 and D054 are RFI sensitive, which caused the calibration and ambient values to malfunction. The LOX and LH₂ tank ullage pressure transducers, D177 through D180, malfunctioned during the ambient test because the LOX and LH₂ tanks were not at ambient pressure during the test. The ambient test values were verified to be within tolerance during the DDAS procedure, H&CO 1B59500.

The torch and water test was performed satisfactorily. Following setup of the console GH₂ supply, the GH₂ igniters, the diffuser water, the deflection plate water, and the aspirator water were functioned in acceptance test sequence. This series of events verified that proper water pressures and torch ignition signals were received.

The stage valve functional checks were initiated by opening and closing the LH₂ and LOX vent valves and fill and drain valves, while the valve operating times were measured.

The LOX and LH₂ prevalues and chilldown shutoff valves were then cycled, and their operating times were measured. The LH₂ directional vent valve was set to the flight position and to the ground position, and the operating times for each position were recorded. All operating times were recorded in the Test Data Table.

4.1.31 (Continued)

The auxiliary hydraulic system was operated, and the proper pressures and levels were verified prior to restrainer link disengagement. The J-2 engine received a step gimbal signal, as well as 1/4 and 1/2 degree sinusoidal inputs at 0.6, 5, and 7 Hz. The checkout proceeded without interruption.

A final dry sequence of the J-2 engine was conducted through the use of simulation commands for ASI ignition and mainstage, to verify the proper operation of the engine, as well as of the ESCS spark monitoring circuitry.

The ullage rocket ignition and jettison EBW units were functionally certified by charging the units and firing them into pulse sensors.

The overfill point level sensors were proven to operate satisfactorily by cycling the sled main fill and replenish valves, with the operation of 2-out-of-3 depletion sensors verifying that the cutoff logic was operational. In addition, the individual ability to create a cutoff was proven for the engine lockout component test power and engine lockout GSE power - EDS1 - EDS2 systems.

A check of the inverter-converter outputs was followed by cycling the PU mass bridge while creating positive and negative error signals for verification of the engine PU valve position. This section was satisfactorily completed.

The stage bus internal power was set up by the use of secondary battery power.

The forward internal/external cycle was completed while switching normal telemetry current on forward bus 1, and PU current on forward bus 2. Following the APS and range safety functional check, aft bus 1 was cycled internal/external with the stage ambient and APS currents being drawn.

Engineering status review indicated that one non-flight transducer, P/N 1A72913-539, was installed on the stage during integrated system test. The transducer was for measurement D576, the LH₂ tank pressure.

There were twenty-three revisions made to the procedure for the following:

- a. Fourteen revisions concerned correction of procedure, TRD, and program errors.

4.1.31 (Continued)

- b. One revision added RACS values to the program, based on calibration data for J-2 engine pressure transducers.
- c. One revision deleted the LOX and LH₂ chilldown inverter voltage and frequency checks. These measurements were checked per revision 16 of the power distribution procedure, H&CO 1B59498.
- d. One revision explained a mainstage pressure OK switch malfunction that occurred during an engineering run. Investigation revealed a broken wire in cable assembly, P/N 1B49399-2. This cable was repaired per FARR A251538.
- e. One revision explained a SIM interrupt on channel 72. The LH₂ pre-valve was cycled while the SIM was disabled. When the SIM was enabled, no valve movement occurred, thus causing the interrupt.
- f. One revision concerned channel malfunctions received due to out-of-tolerance measurements recorded during the DDAS section. Measurements numbers D16 and D54 were out-of-tolerance because these strain gauge transducers are RFI sensitive, causing the calibration and ambient values to malfunction. The calibration and ambient values were verified to be within tolerance during the DDAS procedure, H&CO 1B59500, which was operated in a closed loop mode.
- g. One revision concerned channel malfunctions received due to out-of-tolerance measurements recorded during DDAS automatic checkout. Measurements numbers D177 through D180 were out-of-tolerance because the system was pressurized during this portion of the test, while the procedure was written for ambient pressure values. These measurement values had been verified to be within acceptable tolerances during the DDAS automatic checkout per H&CO 1B59500.
- h. One revision concerned the malfunction printout indicating that the GH₂ crossover had failed to close. The crossover was slow in closing, so the computer saw the valve as being open, causing the malfunction printout.
- i. One revision explained the type statement "MALF - RS1 EBW firing unit arm and engine cutoff not on". These two functions should have been off. The cable assembly, P/N 1B49399-561, was installed at sequencer bus module 404A3A25, but should have been installed on the 404A3A32 module. With the cable properly installed, it prevented RS 1 from generating a cutoff, as well as preventing EDS 2 from turning on the IU talkback.
- j. One revision stated that due to an operator's error in not depressing the cutoff reset during a 15 second delay at step 15502, OLSTOL was entered in order to jump back and repeat a test.

4.1.31.1 Test Data Table, Integrated System Test

CP1-B0 Multiplexer Ambient Measurement and High and Low RACS Voltages

<u>Meas</u> <u>No.</u>	<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
D016	Hi RACS Test	4.148 vdc*	4.000 \pm 0.100 vdc
D016	Lo RACS Test	1.148 vdc*	1.000 \pm 0.100 vdc
D016	Amb Output	79.236 psia	14.700 \pm 70.000 psia
D177	Amb Output	16.782 psia*	14.700 \pm 1.000 psia
D178	Amb Output	16.746 psia*	14.700 \pm 1.000 psia
M068	Hi RACS Test	3.999 vdc	4.000 \pm 0.050 vdc
M068	Lo RACS Test	0.005 vdc	0.000 \pm 0.050 vdc
M068	Amb Output	4.979 vdc	5.000 \pm 0.050 vdc
M024	Hi RACS Test	4.005 vdc	4.000 \pm 0.050 vdc
M024	Lo RACS Test	0.005 vdc	0.000 \pm 0.050 vdc
M024	Amb Output	4.987 vdc	5.000 \pm 0.050 vdc
M025	Hi RACS Test	4.005 vdc	4.000 \pm 0.050 vdc
M025	Lo RACS Test	0.010 vdc	0.000 \pm 0.050 vdc
M025	Amb Output	5.015 vdc	5.000 \pm 0.050 vdc
D043	Amb Output	2241.875 psia	2350.000 \pm 125.000 psia
D018	Hi RACS Test	4.117 vdc	4.152 \pm 0.100 vdc
D018	Lo RACS Test	1.153 vdc	1.169 \pm 0.100 vdc
D018	Amb Output	11.503 psia	14.700 \pm 15.000 psia
D017	Hi RACS Test	4.020 vdc	4.053 \pm 0.100 vdc
D017	Lo RACS Test	1.030 vdc	1.047 \pm 0.100 vdc
D017	Amb Output	10.621 psia	14.700 \pm 70.000 psia
D019	Hi RACS Test	4.010 vdc	4.019 \pm 0.100 vdc
D019	Lo RACS Test	1.015 vdc	1.013 \pm 0.100 vdc
D019	Amb Output	12.903 psia	14.700 \pm 70.000 psia
D160	Hi RACS Test	3.999 vdc	4.000 \pm 0.100 vdc
D160	Lo RACS Test	0.999 vdc	1.000 \pm 0.100 vdc
D160	Amb Output	39.262 psia	14.700 \pm 70.000 psia
D179	Amb Output	18.135 psia*	14.700 \pm 1.000 psia
D180	Amb Output	18.380 psia*	14.700 \pm 1.000 psia
G001	Amb Output	-0.475 deg	-0.300 \pm 0.400 deg
G002	Amb Output	0.098 deg	0.300 \pm 0.400 deg
D225	Hi RACS Test	3.984 vdc	4.000 \pm 0.100 vdc
D225	Lo RACS Test	1.035 vdc	1.000 \pm 0.100 vdc
D225	Amb Output	9.683 psia	14.700 \pm 10.000 psia

DP1-B0 Multiplexer Ambient Measurements and High and Low RACS Voltages

<u>Meas</u> <u>No.</u>	<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
D016	Hi RACS Test	4.133 vdc*	4.000 \pm 0.100 vdc
D016	Lo RACS Test	1.158 vdc*	1.000 \pm 0.100 vdc
D016	Amb Output	86.873 psia*	14.700 \pm 70.000 psia
D177	Amb Output	16.845 psia*	14.700 \pm 1.000 psia

*Out-of-tolerance, Ref revisions f and g

4.1.31.1 (Continued)

<u>Meas No.</u>	<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
D178	Amb Output	16.808 psia*	14.700 \pm 1.000 psia
D054	Hi RACS Test	4.226 vdc*	4.000 \pm 0.100 vdc
D054	Lo RACS Test	1.051 vdc	1.000 \pm 0.100 vdc
D054	Amb Output	20.993 psia*	14.700 \pm 2.000 psia
M068	Hi RACS Test	4.005 vdc	4.000 \pm 0.500 vdc
M068	Lo RACS Test	0.005 vdc	0.000 \pm 0.050 vdc
M068	Amb Output	4.979 vdc	5.000 \pm 0.050 vdc
M024	Hi RACS Test	4.010 vdc	4.000 \pm 0.050 vdc
M024	Lo RACS Test	0.005 vdc	0.000 \pm 0.050 vdc
M024	Amb Output	4.987 vdc	5.000 \pm 0.050 vdc
M025	Hi RACS Test	3.999 vdc	4.000 \pm 0.050 vdc
M025	Lo RACS Test	0.005 vdc	0.000 \pm 0.050 vdc
M025	Amb Output	5.017 vdc	5.000 \pm 0.050 vdc
D014	Amb Output	19.147 psia	14.700 \pm 13.000 psia
D050	Amb Output	12.766 psia	14.700 \pm 3.000 psia
D103	Amb Output	15.384 psia	14.700 \pm 3.000 psia
D105	Hi RACS Test	4.020 vdc	4.000 \pm 0.100 vdc
D105	Lo RACS Test	1.025 vdc	1.000 \pm 0.100 vdc
D105	Amb Output	21.139 psia	14.700 \pm 10.000 psia
C051	Hi RACS Test	4.005 vdc	4.000 \pm 0.074 vdc
C051	Lo RACS Test	-0.005 vdc	0.000 \pm 0.074 vdc
C051	Amb Output	56.506°F	50.000 \pm 15.000°F
D018	Hi RACS Test	4.138 vdc	4.152 \pm 0.100 vdc
D018	Lo RACS Test	1.169 vdc	1.169 \pm 0.100 vdc
D018	Amb Output	12.267 psia	14.700 \pm 15.000 psia
D017	Hi RACS Test	4.025 vdc	4.053 \pm 0.100 vdc
D017	Lo RACS Test	1.030 vdc	1.047 \pm 0.100 vdc
D017	Amb Output	12.142 psia	14.700 \pm 30.000 psia
D019	Hi RACS Test	4.010 vdc	4.019 \pm 0.100 vdc
D019	Lo RACS Test	1.015 vdc	1.013 \pm 0.100 vdc
D019	Amb Output	16.475 psia	14.700 \pm 70.00 psia
D160	Hi RACS Test	3.999 vdc	4.000 \pm 0.100 vdc
D160	Lo RACS Test	0.999 vdc	1.000 \pm 0.100 vdc
D160	Amb Output	35.521 psia	14.700 \pm 70.000 psia
D179	Amb Output	18.197 psia*	14.700 \pm 1.000 psia
D180	Amb Output	18.442 psia*	14.700 \pm 1.000 psia
M006	Amb Output	27.753 vdc	28.000 \pm 2.000 vdc
M007	Amb Output	0.030 vdc	0.000 \pm 1.000 vdc
C001	Hi RACS Test	3.989 vdc	4.000 \pm 0.074 vdc
C001	Lo RACS Test	0.000 vdc	0.000 \pm 0.074 vdc
C001	Amb Output	59.017°F	50.000 \pm 72.000°F
C002	Hi RACS Test	3.994 vdc	4.000 \pm 0.074 vdc
C002	Lo RACS Test	0.000 vdc	0.000 \pm 0.074 vdc
C002	Amb Output	52.701°F	50.000 \pm 48.000°F
C006	Hi RACS Test	4.030 vdc	4.000 \pm 0.074 vdc
C006	Lo RACS Test	-0.005 vdc	0.000 \pm 0.074 vdc
C006	Amb Output	56.728°F	50.000 \pm 18.000°F

* Out-of-tolerance, Ref revisions f and g

4.1.31.1 (Continued)

<u>Meas</u> <u>No.</u>	<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
C199	Hi RACS Test	4.030 vdc	4.000 \pm 0.074 vdc
C199	Lo RACS Test	-0.005 vdc	0.000 \pm 0.074 vdc
C199	Amb Output	57.492°F	50.000 \pm 21.000°F
C138	Hi RACS Test	3.999 vdc	4.000 \pm 0.074 vdc
C138	Lo RACS Test	0.000 vdc	0.000 \pm 0.074 vdc
C138	Amb Output	55.720°F	50.000 \pm 16.000°F
G001	Amb Output	-0.473 deg	-0.300 \pm 0.400 deg
G002	Amb Output	0.362 deg	0.300 \pm 0.400 deg

Valve Functional Checks

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
<u>LH₂ and LOX Prevalves</u>		
Close Time (sec)	0.499	4.000 max
Open Time (sec)	2.005	4.000 max
<u>LH₂ Vent Valve</u>		
Open Time (sec)	0.129	4.000 max
Close Time (sec)	0.369	4.000 max
<u>LOX Vent Valve</u>		
Open Time (sec)	0.123	4.000 max
Close Time (sec)	0.309	4.000 max
<u>LH₂ & LOX Chillover Shutoff Valve</u>		
Close Time (sec)	0.163	4.000 max
Open Time (sec)	0.952	4.000 max
<u>LH₂ Vent Valve</u>		
Open Time (sec)	0.095	4.000 max
Close Time (sec)	0.352	4.000 max
Open Time (sec)	0.096	4.000 max
Close Time (sec)	0.221	4.000 max
<u>LOX Vent Valve</u>		
Open Time (sec)	0.098	4.000 max
Close Time (sec)	0.293	4.000 max
Open Time (sec)	0.098	4.000 max
Close Time (sec)	0.200	4.000 max
<u>LH₂ Fill & Drain Valve</u>		
Open Time (sec)	0.358	4.000 max
Close Time (sec)	2.067	4.000 max
Open Time (sec)	0.343	4.000 max
Close Time (sec)	0.965	4.000 max

4.1.31.1 (Continued)

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
<u>LOX Fill & Drain Valve</u>		
Open Time (sec)	0.292	4.000 max
Close Time (sec)	1.812	4.000 max
Open Time (sec)	0.282	4.000 max
Close Time (sec)	0.904	4.000 max
<u>LH₂ & LOX Prevalves</u>		
Close Time (sec)	0.545	4.000 max
Open Time (sec)	2.021	4.000 max
<u>LH₂ & LOX Chilledown Shutoff Valve</u>		
Close Time (sec)	0.192	4.000 max
Open Time (sec)	0.972	4.000 max
<u>Directional Vent Valve</u>		
Flight Position (sec)	0.174	4.000 max
Ground Position (sec)	1.228	4.000 max

Engine Gimbal Step Commands with Engine Restrainer Links

<u>Position Commands</u>	<u>Excitation (vdc)</u>		<u>T/M Position (deg)</u>		<u>IU Position (deg)</u>	
	<u>Pitch</u>	<u>Yaw</u>	<u>Pitch</u>	<u>Yaw</u>	<u>Pitch</u>	<u>Yaw</u>
0° pitch - 0° yaw	-0.15	0.05	-0.05	-0.01	-0.04	-0.04
1° pitch - 0° yaw	6.40	0.00	0.77	-0.03	0.77	-0.06
0° pitch - 0° yaw	-0.25	0.05	-0.05	-0.03	-0.03	-0.03
1° pitch - 0° yaw	-6.85	-0.05	-1.04	-0.03	-1.03	-0.06
0° pitch - 0° yaw	-0.15	0.05	-0.05	-0.03	-0.04	-0.07
0° pitch - 1° yaw	-0.20	-6.60	-0.02	-0.85	-0.01	-0.84
0° pitch - 0° yaw	-0.25	0.05	-0.00	0.00	-0.01	0.00
0° pitch - 1° yaw	-0.25	6.65	-0.02	1.04	-0.01	1.00
0° pitch - 0° yaw	-0.20	0.00	0.00	-0.01	0.00	-0.04

Engine Gimbal Step Commands, Restrainer Links Dropped

<u>Position Commands</u>	<u>Excitation (vdc)</u>		<u>T/M Position (deg)</u>		<u>IU Position (deg)</u>	
	<u>Pitch</u>	<u>Yaw</u>	<u>Pitch</u>	<u>Yaw</u>	<u>Pitch</u>	<u>Yaw</u>
0° pitch - 0° yaw	-0.20	0.05	-0.02	-0.03	0.00	-0.04
1° pitch - 0° yaw	6.45	0.00	0.96	-0.03	0.96	-0.04
0° pitch - 0° yaw	-0.25	0.00	-0.03	-0.03	-0.03	-0.06
1° pitch - 0° yaw	-6.85	0.05	-1.01	-0.03	-1.00	-0.04
0° pitch - 0° yaw	-0.25	0.00	-0.03	-0.03	-0.03	-0.04
0° pitch - 1° yaw	-0.25	-6.65	-0.00	-1.05	0.00	-1.06
0° pitch - 0° yaw	-0.25	0.05	-0.00	0.00	0.00	-0.01
0° pitch - 1° yaw	-0.25	6.65	0.01	1.04	0.01	1.03
0° pitch - 0° yaw	-0.20	0.05	-0.00	-0.03	0.01	-0.03

4.1.31.1 (Continued)

Engine Gimbal Frequency Response

<u>Axis & Ampl.</u>	<u>Desired Freq (Hz)</u>	<u>Actual Freq (Hz)</u>	<u>Time Lag (sec)</u>	<u>Phase Lag (deg)</u>	<u>Cycles Gimb'd</u>	<u>Sample Time (sec)</u>
Pitch	0.60	0.57	0.895	-182.813	3.8	2.518
0.25 deg	5.00	4.95	0.068	-121.641	14.69	2.521
	7.00	7.01	0.050	-125.508	20.28	2.513
Yaw	0.60	0.58	0.049	10.195	4.07	2.516
0.25 deg	5.00	4.92	0.021	36.211	15.70	2.520
	7.00	6.97	0.162	406.406	22.22	2.552
Pitch	0.60	0.57	0.842	-171.914	3.08	2.544
0.50 deg	5.00	4.97	0.059	-104.766	14.74	2.251
	7.00	7.06	0.043	-108.984	20.21	2.511
Yaw	0.60	0.58	0.059	11.953	4.07	2.517
0.50 deg	5.00	4.95	0.032	57.305	15.86	2.549
	7.00	6.97	0.019	46.406	21.11	2.523

4.1.32 Final Prefire Propulsion System Leak Check (1B70175 D)

Final leak checks for the stage propulsion system were conducted prior to acceptance firing after all other stage checkouts had been completed. The primary purpose of the final prefire leak checks was to test for any external leakage that could occur as a result of system disturbance during checkouts conducted after the prefire propulsion system leak check, reference paragraph 4.1.21. Examples of system disturbance that required a repeat of the external leak checks included removal and replacement of instrumentation, replacement of malfunctioning components, and plumbing connections required to facilitate prefire checkouts.

Checkout was initiated on 9 June 1967, and was completed and certified as acceptable on 12 June 1967. Recorded measurements are listed in Test Data Table 4.1.32.1.

Stage ambient helium system leak checks were conducted with the pneumatic control sphere and the LOX and LH₂ ambient helium repressurization spheres pressurized with helium to 1450 ±50 psig, with the control regulator discharge pressure set at 515 ±50 psig. All portions of the system were checked for external helium leakage with a helium leak detector and LOX compatible bubble solution, AMS 3159. In addition, the pneumatic actuation control modules

4.1.32 (Continued)

were checked for internal leakage by monitoring each module vent port. No leakage was noted.

After satisfactory completion of the ambient helium systems leak check, the cold helium system was leak checked with helium by pressurizing the cold helium spheres to 950 ± 50 psig, and checking all plumbing for external leakage with the helium leak detector. No leaks were detected.

After completing setup operations for pressurizing the LOX and LH₂ tank assembly, preparations for the LOX and LH₂ tank assembly pressure decay checks were made. These were accomplished by closing all engine propellant supply valves to maintain static helium pressure in the tank assembly and monitor any loss in tank pressures over a 30 minute period. The pressure requirements were $15 +0, -1$ psig for the LOX tank and $9 +1, -0$ psig for the LH₂ tank. Prior to the pressurization, gas samples were taken from both tanks and analyzed for helium content. Results of the helium concentration check and the pressure decay check for the LOX and LH₂ tank assembly are listed in the Test Data Table.

Next the control helium bottle fill valve was closed and a 30 minute control sphere pressure decay check was made. While maintaining LOX tank helium pressure at $15 +0, -1$ psig, the LOX propellant supply line (low pressure duct) to the J-2 engine was pressurized with helium at 15 to 30 psig. The entire LOX propellant supply system, recirculation system, and LOX tank fill and drain line were checked for external leakage from the LOX tank, downstream to the J-2 engine, including the LOX turbopump and all related pump discharge plumbing. This included the PU valve, the main LOX shutoff valve (MOV), the ASI valve, and the gas generator oxidizer circuitry terminating at the gas generator oxidizer valve. No external leakage was recorded for the LOX system.

After venting the LOX low pressure duct, the LH₂ low pressure duct (propellant supply to the J-2 engine), was pressurized with helium at 10 to 30 psig while maintaining LOX tank and LH₂ tank pressures at 10 to 15 psig and $10 +0, -1$ psig, respectively. The LH₂ system from the LH₂ tank through the J-2 engine

4.1.32 (Continued)

was then checked for external helium leakage, similarly to the LOX system previously described. No external leaks were detected.

The J-2 engine thrust chamber throat plug was then installed and helium pressure at 9 ± 1 , -0 psig was stabilized between the throat plug and the main oxidizer and fuel thrust chamber valves (MOV and MFV) to conduct the thrust chamber leak checks. The entire J-2 thrust chamber system was then checked for external helium leakage. No leakage was detected. In addition to external leak checks of the thrust chamber system, the actuator drive and idler shaft seal leak checks were conducted for the thrust chamber valves (MOV and MFV). The results are listed in the Test Data Table.

The J-2 engine start system leak check was begun by drying the start tank vent valve actuator. A vacuum pump was attached and the actuator was pumped down to a vacuum of 10 mm of Hg maximum. A heat lamp was applied to the actuator to obtain a surface temperature between 100°F and 150°F . The actuator temperature and vacuum were maintained for a minimum of 2 hours. The start tank system was leak checked by pressurizing the tank with helium to 500 ± 10 psig and checking all connections for external leakage. No leakage was detected. After allowing the start tank pressure to stabilize for 2 hours, the start tank temperature and pressure were measured and recorded. After 1 hour these measurements were repeated to calculate the helium mass decay rate for the start tank. The calculated decay rate was 0.001733 pound-mass/hour, which was acceptable based on an allowable mass decay rate of 0.0066 pound-mass/hour.

The J-2 engine control sphere was then pressurized with helium to between 225 and 250 psig in preparation for engine pneumatic leak checks. The low pressure side leak check was then conducted to determine internal leakage within the engine pneumatic control package. Leakage rates as measured at the pneumatic control module common vent port were within the acceptable tolerances, as listed in the Test Data Table. The engine control sphere pressure was then increased to 300 ± 10 psig and the helium control solenoid was turned on to pressurize the pressure actuated purge system for external leak checks. No leaks were detected. The engine control sphere pressure was then increased to 1450 ± 50 psia for the pneumatic control high pressure side retention test.

4.1.32 (Continued)

After allowing the control sphere pressure to stabilize for 1 hour, the control sphere temperature and pressure were measured and used to calculate the sphere helium mass. This was repeated 1 hour later to obtain a calculated engine control sphere helium mass decay rate of 0.00 pound-mass/hour, which was acceptable based on an allowable decay rate of 0.036 pound-mass/hour.

The LH₂ and LOX tanks and the engine systems were then purged, after which gas samples from the tanks were taken to determine if the helium concentration for the propellant tank assembly was acceptable. Results are listed in the Test Data Table. Tank blanket pressures were then maintained at 5 +0, -1 psig for the LOX tank and 3 +0, -1 psig for the LH₂ tank. All systems, except the LOX and LH₂ tanks, were vented to ambient and secured.

Final checks were made to verify that the umbilical hoses required for static firing were installed, and that the unrequired stage umbilical ports were capped off. The checkout was completed by verifying that the required electrical cables were connected to the proper solenoid valves in the LOX and LH₂ tank pressurization modules.

There were no areas of unacceptable leakage detected, no FARR's were initiated, and the stage was designated acceptable for static firing countdown operations.

Twenty-six revisions were recorded in the procedure as follows:

- a. Eight revisions deleted steps that were no longer required or that applied to S-V stages or to postfire checkout.
- b. Two revisions changed part number callouts to match the latest configuration.
- c. One revision added the caution note "Care must be taken to prevent entry of foreign matter or soap into leak check ports," to prevent freezing of the port under cryogenic conditions.
- d. One revision changed the maximum allowable leakage rate for the pneumatic actuation control modules from 1.2 scim to 6.0 scim.
- e. One revision changed the engine control sphere pressure from 950 ±50 psig to between 250 and 300 psig for personnel safety requirements.
- f. One revision authorized the disconnection, and subsequent reconnection, of plug 403W8P3 from the start tank dump solenoid, to prevent venting of the start tank when personnel were in the engine area.

4.1.32 (Continued)

- g. One revision changed the thrust chamber pressure source from the LH₂ nozzle purge to the LH₂ umbilical purge.
- h. One revision changed test point callouts to obtain umbilical readouts for the main oxidizer valve and the main fuel valve.
- i. One revision removed the caps from the LOX and LH₂ turbine seal cavity bleed lines, as the bleed lines must remain open.
- j. One revision added the stage 4 helium pressure of 300 psig. The new set pressure was required for purging the LH₂ feed system through the main oxidizer valve.
- k. Three revisions corrected procedure errors.
- l. One revision added a caution note warning personnel not to spin the engine flow meter.
- m. One revision authorized an engine control sphere pressure retention test.
- n. One revision authorized the reconnection of pipe assembly, P/N 1B62913, to pipe assembly, P/N 1B65189-1. The disconnection had been accomplished in another procedure.
- o. One revision changed test sequences to provide a more convenient method of pressurizing the LOX and LH₂ low pressure ducts.
- p. One revision authorized the performance of a torque check of the LOX pre valve coupling.

4.1.32.1 Test Data Table, Final Prefire Propulsion System Leak Check

LOX and LH₂ Tank Helium Concentration

<u>Location</u>	<u>He. Concentration (%)</u>	
	<u>Reading</u>	<u>Limits</u>
LOX Tank Top	99.7	75 min
LOX Tank Bottom	99.7	75 min
LH ₂ Tank Top	99.8	75 min
LH ₂ Tank Bottom	99.8	75 min

4.1.32.1 (Continued)

LOX and LH₂ Tank Pressure Decay Test

<u>Function</u>	<u>Initial</u>	<u>Final</u>
LOX Tank Pressure (psig)	14.25	14.25
LH ₂ Tank Pressure (psig)	9.25	9.25

Stage Control Helium Sphere Pressure Decay Test

<u>Function</u>	<u>Initial</u>	<u>Final</u>
Control Sphere Pressure (psig)	1475	1475

Thrust Chamber Valve Actuator Shaft Seal Leak Checks

<u>Function</u>	<u>Measured</u>	<u>Limits</u>
MOV Idler Leakage (scim)	0	3.3 max
MFV Idler Leakage (scim)	0	3.3 max
MOV 2nd Stage Actuator Leakage (scim)	0	3.3 max
MFV Actuator Leakage (scim)	0	3.3 max

Engine Pneumatic Control Package (Low Pressure Side) Leak Check

<u>Test Condition</u>	<u>Vent Port Flow (scim)</u>	
	<u>Measurement</u>	<u>Limits</u>
Helium Control Solenoid On	3.7	20 max
Ignition Phase Solenoid On	3.7	20 max
Mainstage Solenoid On	5.0	20 max

Final Helium Concentration Check

<u>Location</u>	<u>He. Concentration (%)</u>	
	<u>Reading</u>	<u>Limits</u>
LOX Tank Top	100.0	99 min
LOX Tank Bottom	100.0	99 min
LH ₂ Tank Top	99.6	99 min
LH ₂ Tank Bottom	99.9	99 min

4.2 Postfire Stage Checkout

Six postfire procedures were conducted on the stage at Test Stand Beta I following the static acceptance firing, after which the stage was removed and placed in storage at STC. The postfire checkout procedures are described in paragraphs 4.2.1 through 4.2.6.

4.2.1 Stage Power Setup (1B59496 D)

Prior to initiation of automatic postfire checkouts for the stage on Test Stand Beta I, the automatic stage power setup procedure verified the capability of the GSE automatic checkout system (ACS) to control power switching to and within the stage, and ensured that the stage distribution system was not subjected to excessive static loads during setup sequences. After successful demonstration, this procedure was used to establish initial conditions during subsequent postfire automatic stage checkouts.

This checkout was successfully accomplished on 26 June 1967, and was accepted on the same date. Stage power setup measured values were as shown in Test Data Table 4.2.1.1.

The test started by resetting all matrix magnetic latching relays and verifying that the corresponding command relays were in the proper state. The umbilical connectors were verified to be mated, and plugs 404W26P1 and 404W27P1 were verified to be disconnected from the LOX and LH₂ inverters. The bus 4D119 talkback power was turned on and the prelaunch checkout group power was turned off. The forward and aft power buses were transferred to external power. The sequencer power, the engine control bus power, the engine ignition bus power, the APS bus 1 and bus 2 power, and the propellant level sensor power, were all verified to be off. The power to the range safety receivers and EBW firing units was transferred to external and verified to be off. The switch selector checkout indication enable and the flight measurement indication enable were both turned on. The bus 4D131 28 vdc power supply was turned on and the forward bus 1 initial current and voltage were measured.

The range safety system safe and arm device was verified to be in the safe condition. Twenty-seven switch selector functions were then turned off and four were turned on. The forward bus 1 quiescent current was measured, power was turned on to the PCM system group, and its current was measured.

4.2.1 (Continued)

After closing the cold helium supply shutoff valve, the bus 4D111 28 vdc supply was turned on and the aft 1 power supply current and voltage were measured. The sequencer power was then turned on and the aft bus 1 power supply current was remeasured to compute the current drain. Next, the bus 4D121 28 vdc power supply was turned on and the forward bus 2 power supply current and voltage were measured. The forward bus 2 power was then turned on to the prelaunch checkout group and its current was measured.

The RACS system run mode was turned on, and, after verifying that the forward and aft battery load tests were turned off, the DDAS ground station source select switch was manually set to position 1 and the ground station was verified to be in synchronization. A series of checks then verified that stage functions were in the proper state. Forty-one functions were verified to be off and twenty were verified to be on. The LOX and LH₂ pre valve and chill-down shutoff valves were verified to be open, and the LOX and LH₂ vent valves and fill and drain valves were verified to be closed.

The final operations of this automatic procedure measured the forward and aft 5 volt excitation module voltages, the range safety EBW firing unit charging voltages, the aft bus 2 voltage, the forward and aft battery simulator voltages, and the component test power voltage.

There were no malfunctions indicated and no FARR's were written as the result of this test.

Two revisions were made to the procedure as follows:

- a. One revision authorized a FILADD change to the program tolerance for the prelaunch checkout group current. The tolerance was changed from 8 \pm 4 to 4 \pm 4 amps. The tolerance of 8 \pm 4 amps was considered a program error, because normal current draw for the prelaunch checkout group can be as low as 2 amps.
- b. One revision deleted the statement, "At completion of the test, the line printer will print out total time and/or cycles." The total switch selector cycles will be obtained at the end of the work shift, and will be retrieved via typewriter.

4.2.1.1 Test Data Table, Stage Power Setup

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Forward Bus 1 Initial Current (amps)	1.60	20 max
Forward Bus 1 Voltage (vdc)	28.40	28 \pm 2
Forward Bus 1 Quiescent Current (amps)	1.60	5 max
PCM System Group Current (amps)	3.80	5 \pm 3
Aft Bus 1 Power Supply Current (amps)	0.30	2 max
Aft Bus 1 Voltage (vdc)	28.48	28 \pm 2
Sequencer Power (amps)	0.10	3 max
Forward Bus 2 Power Supply Current (amps)	0.70	2 max
Forward Bus 2 Voltage (vdc)	27.76	28 \pm 2
Prelaunch Checkout Group Current (amps)	0.20	4 \pm 4
Aft 5 Volt Excitation Module Voltage (vdc)	5.02	5.0 \pm 0.030
Fwd 1 5 Volt Excitation Module Voltage (vdc)	5.00	5.0 \pm 0.030
Fwd 2 5 Volt Excitation Module Voltage (vdc)	4.99	5.0 \pm 0.030
RS 1 EBW Firing Unit Charging Voltage (vdc)	0.00	0 \pm 1
RS 2 EBW Firing Unit Charging Voltage (vdc)	0.00	0 \pm 1
Aft Bus 2 Voltage (vdc)	0.00	0 \pm 1
Forward Battery 1 Voltage (vdc)	0.08	0 \pm 1
Forward Battery 2 Voltage (vdc)	0.00	0 \pm 1
Aft Battery 1 Voltage (vdc)	0.00	0 \pm 1
Aft Battery 2 Voltage (vdc)	0.00	0 \pm 1
Component Test Power Voltage (vdc)	0.56	0 \pm 1

4.2.2 Stage Power Turnoff (1B59497 D)

The stage power turnoff procedure was used for automatic shutdown of the stage power distribution system, returning the stage to the de-energized condition after completion of the various system checkout procedures, during postfire testing of the stage on Test Stand Beta I. The procedure de-activated stage relays so that no current flowed from the battery simulators through the stage wiring. All internal/external transfer relays were set to the external condition.

Satisfactory demonstration of this procedure was accomplished and accepted on 26 June 1967. Stage power turnoff measurement values for this demonstration issue are tabulated in Test Data Table 4.2.2.1. Following this test, the stage power turnoff procedure was used to shutdown the stage at the conclusion of various automatic checkouts conducted during Beta I postfire operations.

The automatic stage power turnoff started with a verification that the umbilical connectors were mated and that the flight measurement indication enable was turned on. The bus 4D119 talkback power, the forward bus 1 and aft bus 1 28 vdc power supplies, and the sequencer power, were all verified to be on. The forward bus 1 and aft bus 1 voltages were then measured.

4.2.2 (Continued)

The switch selector functions were then turned off, and a series of checks verified that the stage electrical functions were in a proper state of off or reset. The forward and aft bus power supplies were verified to be off, and the forward and aft bus battery simulator voltages were measured. The stage buses were then transferred to external power, and the forward and aft stage bus voltages were measured. The EBW pulse sensor power was turned off, and the range safety receivers and EBW firing units were transferred to external power. The range safety system safe and arm device was verified to be on safe, and the bus 4D119 talkback power was turned off. The matrix magnetic latching relays were then reset, completing this demonstration run for stage power turnoff.

There were no discrepancies recorded by FARR's against the test. One revision was made to delete the requirement for printout of time and cycle data. This data is retrieved via the typewriter at the end of each shift.

4.2.2.1 Test Data Table, Stage Power Turnoff

<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
Forward Bus 1 Voltage, Power On (vdc)	28.44	28 \pm 2
Aft Bus 1 Voltage, Power On (vdc)	28.40	28 \pm 2
Forward Bus 1 Battery Simulator Voltage (vdc)	0.00	0 \pm 2
Forward Bus 2 Battery Simulator Voltage (vdc)	0.08	0 \pm 2
Aft Bus 1 Battery Simulator Voltage (vdc)	0.00	0 \pm 2
Aft Bus 2 Battery Simulator Voltage (vdc)	0.08	0 \pm 2
Forward Bus 1 Voltage, Power Off (vdc)	0.16	0 \pm 1.0
Forward Bus 2 Voltage, Power Off (vdc)	0.04	0 \pm 1.0
Aft Bus 1 Voltage, Power Off (vdc)	0.04	0 \pm 1.0
Aft Bus 2 Voltage, Power Off (vdc)	0.00	0 \pm 1.0

4.2.3 Final Propulsion System Leak Check (1B70175 D)

Final leak checks for the stage propulsion system were conducted after the acceptance firing to certify the integrity of the stage systems. The primary purpose of the final postfire leak check was to test for any external leakage that could occur as a result of system disturbance during postfire checkout. Examples of system disturbances requiring a repeat of external leak checks included removal and replacement of instrumentation, replacement of malfunctioning components, and plumbing connections required to facilitate postfire checkouts.

4.2.3 (Continued)

Initiated on 26 June 1967, the checkout was completed on 30 June 1967, and was certified as acceptable on 5 July 1967. Recorded measurements are listed in Test Data Table 4.2.3.1.

After a preliminary test equipment setup, the stage ambient helium system leak checks were conducted. The pneumatic control sphere and the LOX and LH₂ ambient repressurization spheres were pressurized to 1450 ±50 psia, with the control regulator discharge pressure set at 515 ±50 psig. All portions of the system were checked for external helium leakage with a helium leak detector or LOX compatible bubble solution, AMS 3159. In addition, the pneumatic actuation control modules were checked for internal leakage by monitoring each module vent port for the 6.0 scim maximum allowable leakage. No leaks were detected.

After satisfactory completion of the ambient helium systems leak check, the cold helium system was leak checked with helium by pressurizing the cold helium spheres to 950 ±50 psig, and checking all plumbing for external leakage with a helium leak detector. No leaks were detected.

The LOX and LH₂ tank assembly pressure decay checks were conducted next. These were accomplished by closing all engine supply valves to maintain static helium pressure in the tank assembly, and monitoring any loss in tank pressures over a 30 minute period. The pressure requirements were 15 +0, -1 psig for the LOX tank and 9 +1, -0 psig for the LH₂ tank. Prior to the pressurization, gas samples were taken from both tanks and analyzed for percentage of helium gas. The results of the helium concentration check and the pressure decay check for the LOX and LH₂ tank assembly are listed in the Test Data Table.

While maintaining the LOX tank helium pressure at 15 +0, -1 psig, the LOX propellant supply line (low pressure duct) to the J-2 engine was pressurized with helium at 15 to 30 psig. The entire LOX propellant supply system, recirculation system, and tank fill and drain line, were checked for external leakage from the LOX tank downstream to the J-2 engine, including the LOX turbopump and all related pump discharge plumbing. This included the PU valve, the main shutoff valve (MOV), the ASI valve, and the gas generator oxidizer circuitry terminating at the gas generator oxidizer valve. No external leakage was recorded for the LOX system.

4.2.3 (Continued)

After venting the LOX low pressure duct, the LH₂ low pressure duct (propellant) supply to the J-2 engine was pressurized with helium at 10 to 30 psig while maintaining LOX and LH₂ tank pressures at 10 to 15 psig and 10 +0, -1 psig, respectively. The LH₂ system from the LH₂ tank through the J-2 engine was then checked for external helium leakage similarly to the LOX system previously described. No external leaks were detected.

The J-2 engine control sphere was then pressurized to between 225 and 250 psig in preparation for the engine pneumatic system leak checks. Leakage rates as measured at the pneumatic control module common vent port were within the acceptable limits, as listed in the Test Data Table. The engine control sphere pressure was set at 1440 ±40 psig for the pneumatic control high pressure retention tests. After allowing the control sphere pressure to stabilize for 1 hour, the sphere temperature and pressure were measured and used to calculate the sphere helium mass. This was repeated 1 hour later to obtain a calculated engine control sphere helium mass decay rate of 0.0 pound-mass/hour, which was acceptable based on an allowable decay rate of 0.036 pound-mass/hour.

The LH₂ and LOX tanks and engine systems were then purged in preparation for stage storage. The engine checkout system was opened, and the engine propellant system was purged for 15 minutes through the gas generator bleed valves and chilldown return line, and then through the main oxidizer valve out the thrust chamber. The LOX dome, the LOX gas generator injector, and the engine start tank were then purged for 15 minutes.

The LOX and LH₂ tanks and the engine start tank were vented to ambient. The thrust chamber and exhaust system were purged until a moisture sample indication of 7500 ppm was obtained. The thrust chamber purge was then secured and a desiccant unit was installed. The moisture concentration in the LOX and LH₂ tanks was recorded as less than 750 ppm. Desiccant units were installed in the LOX and LH₂ tanks and the stage was ready for storage.

4.2.3 (Continued)

There were thirty-two revisions written to the procedure for the following:

- a. Twelve revisions deleted steps that were no longer required, or that applied to S-V stages or to prefire checkout.
- b. Two revisions changed test point callouts to obtain umbilical readouts for the main oxidizer valve, the main fill valve, the LOX low pressure duct, and the LH₂ low pressure duct.
- c. Two revisions added and outlined the steps required to perform prestorage purges of the J-2 engine to meet Rocketdyne storage requirements.
- d. Two revisions changed part number callouts to match the latest configuration.
- e. One revision authorized the installation and subsequent removal of a burst disk assembly, P/N 1B35826-1, between the LH₂ vent hose and the facility interface, to leakcheck the facility flex hose.
- f. One revision deleted time cycle requirements for the ambient helium spheres.
- g. One revision raised the maximum allowable leakage for the pneumatic actuation control module from 1.2 to 6.0 scim.
- h. One revision authorized disconnecting and subsequently reconnecting the pneumatic power control module connector, 404W2P30, to prevent venting of the engine start tank while personnel were in the engine area.
- i. One revision added new leak check points to a previous revision.
- j. One revision lowered the stage 1 system pressure from 950 ±50 psia to 250 ±50 psia for personnel safety.
- k. One revision authorized temporary disconnection of pipe assembly, P/N 1B58808-1, from pipe assembly, P/N 1B62912, to prevent over-pressurization of the LH₂ vent system. This revision also contained a provision for a return to the original configuration.
- l. One revision added requirements for helium concentration checks to be made on the LOX and LH₂ tanks.
- m. One revision authorized the performance of a torque check of the LOX prevalve coupling.
- n. One revision changed the sequence of a test to provide a higher degree of accuracy.
- o. One revision added requirements for an engine control sphere pressure retention test.
- p. One revision deleted steps that were to be accomplished on a later revision.
- q. One revision deleted a previous revision.
- r. One revision corrected a procedural error.

4.2.3.1 Test Data Table, Propulsion System Leak Checks

LOX and LH₂ Tank Helium Concentration

<u>Location</u>	<u>He Concentration (%)</u>	
	<u>Reading</u>	<u>Limits</u>
LOX Tank Top	96.97	75 min
LOX Tank Bottom	94.55	75 min
LH ₂ Tank Top	99.19	75 min
LH ₂ Tank Bottom	91.91	75 min

LOX and LH₂ Tank Pressure Decay Test

<u>Function</u>	<u>Initial</u>	<u>Final</u>
LOX Tank Pressure (psig)	14	14
LH ₂ Tank Pressure (psig)	9	9

Stage Control Helium Sphere Pressure Decay Test

<u>Function</u>	<u>Initial</u>	<u>Final</u>
Control Sphere Pressure (psig)	675	675

Engine Pneumatic Leak and Functional Checks

<u>Test Condition</u>	<u>Leakage (scim)</u>	
	<u>Measurement</u>	<u>Limits</u>
Pneumatic Control Package Mainstage solenoid valve On	4.8	20 max
Pneumatic Control Package Bleed Poppet Installed	8.4	20 max

Final Moisture Content Check

<u>Location</u>	<u>Moisture (ppm)</u>	
	<u>Reading</u>	<u>Limits</u>
LOX Tank Top	520	750
LOX Tank Bottom	740	750
LH ₂ Tank Top	200	750
LH ₂ Tank Bottom	600	750

4.2.4 Integrated Systems Test (1B59514 E)

This postfire automatic checkout verified the design integrity and operational capability of the S-IVB stage and facility systems which were functional during propellant loading and static acceptance firing.

The automatic and manual test sequences performed during this checkout were conducted on 28 June 1967, and were accepted on 6 July 1967.

4.2.4 (Continued)

The stage power setup established initial conditions and systematically applied power to the stage buses and systems required for operation of the test.

The GSE valve functional checkout established an ambient condition in the pneumatic console by bleeding down all regulators and resetting them to pre-determined values. All console and sled valves used in the propellant loading and static acceptance firing were cycled, and the heat exchanger was functioned.

The telemetry and DDAS systems were tested next, with the PCM transmitter operated open loop. The telemetry 5 step calibration, the high and low RACS, and special calibrations of flows, speeds, and frequencies were commanded to provide verification of all calibration techniques. The parameters on the CP1-B0 and DP1-B0 multiplexers and remote analog and digital submultiplexers, which were required for loading or firing, were verified by receipt of proper response through open loop PCM transmissions. At the conclusion of DDAS, the output was again received by the 600 Hz VCO. During the CP1-B0 multiplexer test, thirty-seven functions were verified to be off while sixteen were on. The DP1-B0 multiplexer test section verified that nine functions were off and thirteen were on. Measurements recorded for the multiplexer tests are listed in Test Data Table 4.2.4.1.

The torch and water test was performed satisfactorily. Following setup of the console GH_2 supply, the GH_2 igniters, the diffuser water, the deflection plate water, and the aspirator water were functioned in acceptance test sequence. This series of events verified that proper water pressures and torch ignition signals were received.

The stage valve functional checks were next. The LH_2 and LOX vent valves and fill and drain valves were opened and closed, while the valve operating times were measured. The LOX and LH_2 prefill valves and chilldown shutoff valves were closed and opened, while the operating times were measured. Valve operating times are listed in the Test Data Table.

4.2.4 (Continued)

Engine gimbal testing followed the stage valve functional tests. The auxiliary hydraulic system was operated while proper pressures and levels were verified prior to restrainer link disengagement. A step gimbal signal, and 1/4 and 1/2 degree sinusoidal inputs at 0.6, 5, and 7 Hz were applied to the J-2 engine hydraulic pitch and yaw actuators. The recorded gimbal data is shown in the Test Data Table.

A final dry sequence of the J-2 engine was conducted through the use of simulation commands for ASI ignition and mainstage, to verify the proper operation of the engine, as well as of the ESCS spark monitoring circuitry.

The ullage rocket ignition and jettison EBW units were functionally certified by charging the units and firing them into pulse sensors.

The overfill point level sensors and depletion point level sensors were proven to operate satisfactorily by cycling the sled main fill and replenish valves, with the operation of 2-out-of-3 depletion sensors verifying the cutoff logic operation. In addition, the capability of the EDS 1 and EDS 2 systems to cutoff the engine lockout component test power and engine lockout GSE power was proven.

The propellant utilization system test was a check of the inverter-converter outputs, followed by cycling the PU mass bridge while creating positive and negative error signals for verification of the engine PU valve position.

The stage bus internal power was set up by the use of secondary battery power. The forward internal/external cycle was completed while switching normal telemetry current on forward bus 1, and PU current on forward bus 2. Following the APS and range safety functional check, aft bus 1 was cycled internal/external while the stage ambient and APS currents were measured.

There were no discrepancies documented by FARR's as a result of integrated systems testing. All problem areas were resolved by the thirty-three revisions recorded in the procedure as follows:

- a. Eleven revisions concerned correction of TRD and program errors.
- b. Four revisions updated the program to conform to current requirements.

4.2.4 (Continued)

- c. Four revisions added, modified, or deleted manual test setups required prior to automatic testing.
- d. One revision entered the necessary PU constants into the program.
- e. One revision added the required J-2 engine transducer calibration data into the program.
- f. One revision deleted the LOX and LH₂ chilldown inverter voltage and frequency checks. The inverter load simulators had not been reworked in time for use during the integrated systems test. The inverter checks were rescheduled for poststorage checkout.
- g. Four revisions attributed SIM interrupts and a channel 7 lockout to operator setup error.
- h. Two revisions concerned out-of-tolerance GSE valve measurements not applicable to the stage hardware.
- i. One revision entered the ambient temperature into the program as requested by the computer.
- j. Three revisions concerned out-of-tolerance measurements for measurement numbers D050 and D054. These were expected since the transducers had been previously rejected on FARR's A255206 and A251588, and were scheduled for poststorage replacement and checkout.
- k. One revision deleted propellant tank pressurization during the test, because the tanks were on desiccant checks following rework of LOX pre valve leakage.

Engineering status review indicated that two non-flight transducers were installed on the stage for interim use during this test. These were measurement D576, P/N 1A72913-539, LH₂ tank pressure; and the Rocketdyne J-2 engine ignition detection probe, P/N NA5-27298-T2.

4.2.4.1 Test Data Table, Integrated Systems Test

CPl-B0 Multiplexer Ambient Measurements and High and Low RACS Voltages

<u>Meas No.</u>	<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
D016	Hi RACS Test	3.994 vdc	4.000 \pm 0.100 vdc
D016	Lo RACS Test	0.964 vdc	1.000 \pm 0.100 vdc
D016	Amb Output	-54.419 psia	14.700 \pm 70.000 psia
D177	Amb Output	14.917 psia	14.700 \pm 1.000 psia
D178	Amb Output	14.706 psia	14.700 \pm 1.000 psia
MO68	Hi RACS Test	3.999 vdc	4.000 \pm 0.050 vdc
MO68	Lo RACS Test	0.005 vdc	0.000 \pm 0.050 vdc
MO68	Amb Output	4.979 vdc	5.000 \pm 0.050 vdc

4.2.4.1 (Continued)

<u>Meas</u> <u>No.</u>	<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
M024	Hi RACS Test	4.005 vdc	4.000 \pm 0.050 vdc
M024	Lo RACS Test	0.010 vdc	0.000 \pm 0.050 vdc
M024	Amb Output	4.987 vdc	5.000 \pm 0.050 vdc
M025	Hi RACS Test	3.999 vdc	4.000 \pm 0.050 vdc
M025	Lo RACS Test	0.000 vdc	0.000 \pm 0.050 vdc
M025	Amb Output	5.016 vdc	5.000 \pm 0.050 vdc
D043	Amb Output	2421.938 psia	2350.000 \pm 125.000 psia
D018	Hi RACS Test	4.138 vdc	4.152 \pm 0.100 vdc
D018	Lo RACS Test	1.158 vdc	1.169 \pm 0.100 vdc
D018	Amb Output	16.084 psia	14.700 \pm 15.000 psia
D017	Hi RACS Test	4.051 vdc	4.053 \pm 0.100 vdc
D017	Lo RACS Test	1.056 vdc	1.047 \pm 0.100 vdc
D017	Amb Output	19.743 psia	14.700 \pm 30.000 psia
D019	Hi RACS Test	4.020 vdc	4.019 \pm 0.100 vdc
D019	Lo RACS Test	1.020 vdc	1.013 \pm 0.100 vdc
D019	Amb Output	23.617 psia	14.700 \pm 70.000 psia
D160	Hi RACS Test	3.984 vdc	4.000 \pm 0.100 vdc
D160	Lo RACS Test	0.994 vdc	1.000 \pm 1.000 vdc
D160	Amb Output	31.782 psia	14.700 \pm 70.000 psia
D179	Amb Output	14.633 psia	14.700 \pm 1.000 psia
D180	Amb Output	14.897 psia	14.700 \pm 1.000 psia
G001	Amb Output	-0.504 deg	-0.300 \pm 0.400 deg
G002	Amb Output	0.083 deg	0.300 \pm 0.400 deg
D225	Hi RACS Test	3.979 vdc	4.000 \pm 0.100 vdc
D225	Lo RACS Test	1.046 vdc	1.000 \pm 0.100 vdc
D225	Amb Output	10.228 psia	14.700 \pm 10.00 psia

DPI-BO Multiplexer Ambient Measurements and High and Low RACS Voltages

<u>Meas</u> <u>No.</u>	<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
D016	Hi RACS Test	3.989 vdc	4.000 \pm 0.100 vdc
D016	Lo RACS Test	0.969 vdc	1.000 \pm 0.100 vdc
D016	Amb Output	-50.600 psia	14.700 \pm 70.000 psia
D177	Amb Output	14.917 psia	14.700 \pm 1.000 psia
D178	Amb Output	14.768 psia	14.700 \pm 1.000 psia
D054	Hi RACS Test	-0.123 vdc*	4.000 \pm 0.100 vdc
D054	Lo RACS Test	-0.123 vdc*	1.000 \pm 0.100 vdc
D054	Amb Output	104.645 psia*	14.700 \pm 2.000 psia
M068	Hi RACS Test	3.999 vdc	4.000 \pm 0.050 vdc
M068	Lo RACS Test	0.005 vdc	0.000 \pm 0.050 vdc
M068	Amb Output	4.978 vdc	5.000 \pm 0.050 vdc
M024	Hi RACS Test	4.010 vdc	4.000 \pm 0.050 vdc
M024	Lo RACS Test	0.005 vdc	0.000 \pm 0.050 vdc

* Out-of-tolerance, Ref revision j

4.2.4.1 (Continued)

<u>Meas</u> <u>No.</u>	<u>Function</u>	<u>Measurement</u>	<u>Limits</u>
M024	Amb Output	4.986 vdc	5.000 \pm 0.050 vdc
M025	Hi RACS Test	3.999 vdc	4.000 \pm 0.050 vdc
M025	Lo RACS Test	0.010 vdc	0.000 \pm 0.050 vdc
M025	Amb Output	5.016 vdc	5.000 \pm 0.050 vdc
D014	Amb Output	17.729 psia	14.700 \pm 13.000 psia
D050	Amb Output	-6.383 psia*	14.700 \pm 3.000 psia
D103	Amb Output	15.384 psia	14.700 \pm 3.000 psia
D105	Hi RACS Test	4.071 vdc	4.000 \pm 0.100 vdc
D105	Lo RACS Test	1.051 vdc	1.000 \pm 0.100 vdc
D105	Amb Output	20.048 psia	14.700 \pm 10.000 psia
C051	Hi RACS Test	4.005 vdc	4.000 \pm 0.074 vdc
C051	Lo RACS Test	-0.005 vdc	0.000 \pm 0.074 vdc
C051	Amb Output	85.076°F	84.000 \pm 15.000°F
D018	Hi RACS Test	4.138 vdc	4.152 \pm 0.100 vdc
D018	Lo RACS Test	1.148 vdc	1.169 \pm 0.100 vdc
D018	Amb Output	15.320 psia	14.700 \pm 15.000 psia
D017	Hi RACS Test	4.051 vdc	4.053 \pm 0.100 vdc
D017	Lo RACS Test	1.056 vdc	1.047 \pm 0.100 vdc
D017	Amb Output	19.743 psia	14.700 \pm 30.000 psia
D019	Hi RACS Test	4.020 vdc	4.019 \pm 0.100 vdc
D019	Lo RACS Test	1.020 vdc	1.013 \pm 0.100 vdc
D019	Amb Output	23.617 psia	14.700 \pm 70.000 psia
D160	Hi RACS Test	3.989 vdc	4.000 \pm 0.100 vdc
D160	Lo RACS Test	0.994 vdc	1.000 \pm 0.100 vdc
D160	Amb Output	31.782 psia	14.700 \pm 70.000 psia
D179	Amb Output	14.695 psia	14.700 \pm 1.000 psia
D180	Amb Output	14.897 psia	14.700 \pm 1.000 psia
M006	Amb Output	28.122 vdc	28.000 \pm 2.000 vdc
M007	Amb Output	0.000 vdc	0.000 \pm 1.000 vdc
C001	Hi RACS Test	3.989 vdc	4.000 \pm 0.074 vdc
C001	Lo RACS Test	0.000 vdc	0.000 \pm 0.074 vdc
C001	Amb Output	87.711°F	84.000 \pm 72.000°F
C002	Hi RACS Test	3.994 vdc	4.000 \pm 0.074 vdc
C002	Lo RACS Test	0.000 vdc	0.000 \pm 0.074 vdc
C002	Amb Output	80.479°F	84.000 \pm 48.000°F
C006	Hi RACS Test	4.025 vdc	4.000 \pm 0.074 vdc
C006	Lo RACS Test	0.000 vdc	0.000 \pm 0.074 vdc
C006	Amb Output	86.367°F	84.000 \pm 18.000°F
C199	Hi RACS Test	4.025 vdc	4.000 \pm 0.074 vdc
C199	Lo RACS Test	-0.005 vdc	0.000 \pm 0.074 vdc
C199	Amb Output	88.539°F	84.000 \pm 21.000°F
C138	Hi RACS Test	3.989 vdc	4.000 \pm 0.074 vdc
C138	Lo RACS Test	0.000 vdc	0.000 \pm 0.074 vdc
C138	Amb Output	83.111°F	84.000 \pm 16.000°F
G001	Amb Output	-0.488 deg	-0.300 \pm 0.400 deg
G002	Amb Output	0.362 deg	0.300 \pm 0.400 deg

* Out-of-tolerance, Ref revision j

4.2.4.1 (Continued)

Valve Functional Check

<u>Valve</u>	<u>Function</u>	<u>Measurement</u>
LH ₂ Vent Valve	Open Time (sec)	0.126
	Close Time (sec)	0.407
LOX Vent Valve	Open Time (sec)	0.126
	Close Time (sec)	0.331
LH ₂ Vent Valve	Open Time (sec)	0.098
	Close Time (sec)	0.381
	Open Time (sec)	0.096
	Close Time (sec)	0.216
LOX Vent Valve	Open Time (sec)	0.094
	Close Time (sec)	0.303
	Open Time (sec)	0.097
	Close Time (sec)	0.204
LH ₂ Fill & Drain Valve	Open Time (sec)	0.364
	Close Time (sec)	2.021
	Open Time (sec)	0.345
	Close Time (sec)	0.938
LOX Fill & Drain Valve	Open Time (sec)	0.299
	Close Time (sec)	1.868
	Open Time (sec)	0.278
	Close Time (sec)	0.890
LH ₂ & LOX Prevalves	Close Time (sec)	0.561
	Open Time (sec)	2.076
LH ₂ & LOX C/D Shutoff Valves	Close Time (sec)	0.196
	Open Time (sec)	0.969
LH ₂ & LOX Prevalves	Close Time (sec)	0.513
	Open Time (sec)	2.054
LH ₂ & LOX C/D Shutoff Valves	Close Time (sec)	0.162
	Open Time (sec)	0.942
LH ₂ Directional Vent Valve	Flight Position (sec)	0.184
	Ground Position (sec)	1.199

Engine Gimbal Step Commands with Engine Restraint Links

<u>Position Commands</u>	<u>Excitation (vdc)</u>		<u>T/M Position (deg)</u>		<u>IU Position (deg)</u>	
	<u>Pitch</u>	<u>Yaw</u>	<u>Pitch</u>	<u>Yaw</u>	<u>Pitch</u>	<u>Yaw</u>
0° pitch - 0° yaw	-0.15	5.00	-0.10	-0.03	-0.10	-0.06
1° pitch - 0° yaw	6.35	-0.15	0.77	-0.01	0.78	-0.03
0° pitch - 0° yaw	-0.20	-4.65	-0.13	-0.03	-0.10	-0.06
1° pitch - 0° yaw	-6.80	-4.55	-1.05	-0.01	-1.06	-0.03
0° pitch - 0° yaw	-0.25	2.50	-0.13	-0.01	-0.15	-0.06

4.2.4.1 (Continued)

Position Commands	Excitation (vdc)		T/M Position (deg)		IU Position (deg)	
	Pitch	Yaw	Pitch	Yaw	Pitch	Yaw
0° pitch - 1° yaw	-0.20	-6.55	-0.10	-0.83	-0.09	-0.86
0° pitch - 0° yaw	-0.20	0.00	-0.10	0.00	-0.10	-0.01
0° pitch - 1° yaw	-0.15	6.70	-0.10	1.02	-0.09	1.00
0° pitch - 0° yaw	-0.20	0.10	-0.08	-0.01	-0.09	-0.03

Engine Gimbal Step Commands, Restrainer Links Dropped

Position Commands	Excitation (vdc)		T/M Position (deg)		IU Position (deg)	
	Pitch	Yaw	Pitch	Yaw	Pitch	Yaw
0° pitch - 0° yaw	-0.15	0.05	-0.10	-0.03	-0.12	-0.04
1° pitch - 0° yaw	6.50	0.05	0.86	-0.03	0.86	-0.06
0° pitch - 0° yaw	-0.25	0.05	-0.14	-0.03	-0.13	-0.06
1° pitch - 0° yaw	-6.90	0.05	-1.10	-0.03	-1.09	-0.06
0° pitch - 0° yaw	-0.25	0.05	-0.11	-0.03	-0.12	-0.06
0° pitch - 1° yaw	-0.15	-6.65	-0.10	-1.05	-0.09	-1.06
0° pitch - 0° yaw	-0.20	0.05	-0.10	0.02	-0.09	-0.01
0° pitch - 1° yaw	-0.15	6.70	-0.10	1.02	-0.09	0.99
0° pitch - 0° yaw	-0.25	0.10	-0.08	-0.01	-0.09	-0.06

Engine Gimbal Frequency Response

Axis & Ampl	Desired Freq (Hz)	Actual Freq (Hz)	Time Lag (sec)	Phase Lag (deg)	Cycles Gimb'd	Sample Time (sec)
Pitch 0.25 deg	0.60	0.57	0.864	-176.133	3.07	2.515
	5.00	4.95	0.063	-112.852	14.66	2.514
	7.00	6.97	0.045	-112.500	19.92	2.512
Yaw 0.25 deg	0.60	0.57	0.085	17.227	4.08	2.517
	5.00	4.97	0.033	59.414	15.91	2.515
	7.00	6.92	0.016	38.672	21.02	2.515
Pitch 0.50 deg	0.60	0.57	0.831	-169.453	3.07	2.516
	5.00	4.97	0.053	-94.219	14.73	2.521
	7.00	6.97	0.040	-100.195	19.91	2.512
Yaw 0.50 deg	0.60	0.57	0.064	13.008	4.07	2.516
	5.00	4.95	0.035	62.578	15.82	2.516
	7.00	6.92	0.021	53.438	20.94	2.520

4.2.5 Postfire Hydraulic Systems Operating and Securing (1B41006 A)

Contained in this procedure were the instructions necessary to obtain postfire and poststorage closed loop fluid samples, and to prepare the hydraulic system for removal of the stage from the test stand for shipment to the VCL.

4.2.5 (Continued)

This procedure was initiated on 29 June 1967, and was completed on 30 June 1967. Prior to the start of the checkout, the Model DSV-4B-358 hydraulic pumping unit (HPU), P/N 1A67443-1, was flushed and checked for hydraulic fluid cleanliness, then connected to the stage hydraulic system by pressure and return hoses.

After the stage air tank was initially pressurized, the accumulator/reservoir was pressurized to 2350 psig with nitrogen gas. Verification was made that all components of the stage hydraulic system were securely installed, and that each hydraulic connection was properly torqued. All bleed valves were verified to be closed, and all signs of hydraulic fluid were rinsed from the external system.

A closed loop system fluid sample was obtained and found to be within the cleanliness requirements. (Less than 1340 particles in the 10-25 micron range, 530 particles in the 25-50 micron range, 60 particles in the 50-100 micron range, and 10 particles over 100 microns.)

For the hydraulic system air content test, the system was pressurized to 3650 \pm 50 psig, using the HPU. After 3 minutes, the HPU was turned off and the system pressure was allowed to decay to 180 \pm 5 psig. Sufficient hydraulic fluid was then drained from the system to reduce the system pressure to 80 \pm 5 psig. The amount of fluid drained was verified to be less than 16 milliliters, indicating that filling and bleeding of the stage hydraulic system had been satisfactorily accomplished.

The stage air supply bottle and the auxiliary pump case were depressurized. After complete depressurization of the pump case, the bleed plug was retorqued and safetied.

The GN₂ accumulator was depressurized, all auxiliary equipment was removed from the hydraulic system, and all sample ports were capped. The actuator midstroke locks were installed, the accumulator/reservoir drain hose was removed, and a plastic dust cover was installed over the reservoir low pressure relief valve.

Engineering comments indicate that all parts were installed at the start of the test. No problems were encountered and the procedure was accepted by Engineering on 30 June 1967.

4.2.5 (Continued)

Two revisions were made to the procedure for the following:

- a. One revision authorized the depressurization of the GN₂ accumulator to ambient to allow removal of the pitch and yaw actuator delta-P transducer, P/N 1A72914-1, per engineering instructions.
- b. One revision reran the closed loop system sample section to verify system cleanliness after removal of the delta-P transducer.

4.2.6 Postfire Forward Skirt Thermoconditioning System Checkout (1B41883 A)

The forward skirt thermoconditioning system (TCS), P/N 1B38426-513, was checked in preparation for shipment of the stage to the Sacramento Test Center Vehicle Checkout Laboratory (VCL) for storage.

The procedure was initiated on 30 June 1967, with the Model DSV-4B-359 thermoconditioning servicer, P/N 1A78829-1, being disconnected from the stage TCS.

The TCS was then drained of all water/methanol fluid by pressurizing the TCS with 32 \pm 1 psig of GN₂. When all fluid was drained from the TCS, a GN₂ purge flow of 5 \pm 1 psig was established and maintained for 2 hours to ensure that the TCS was free of moisture and that the dew point was less than 44°F.

The TCS fluid supply and return ports were then capped with quick disconnects, and the system was certified as secure on 6 July 1968.

IIS 364664 documented that the drying purge was operated for only 1 hour, rather than 2 hours as required. The purge was re-established for 2 hours to meet the requirements of this procedure.

Four revisions were made to this checkout for the following.

- a. One revision deleted the requirement for TCS leak checks, as the supply coupling, P/N 1B28430-1, was removed and a leak check will be required on re-installation of the coupling.
- b. One revision gave instructions to secure the TCS for the week end of 31 June 1967.
- c. One revision re-established the GN₂ purge for 2 hours to clear IIS 364664.
- d. One revision deleted the water/methanol cleanliness test, the specific gravity test, the TCS delta-P test, and the final drying procedure, as the stage was scheduled for an extended period of storage. All deleted sections will be accomplished upon reactivation of the stage.

SECTION 5

POSTRETENTION

5.0 POSTRETENTION

The information in this section will be added 21 days after the stage is shipped from STC.

APPENDIX I

TESTING SEQUENCE

1967				
MAR	APR	MAY	JUN	JUL

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APPENDIX II

TABLES

TABLE I. OPEN FARRS RECEIVED FROM THE SPACE SYSTEMS CENTER

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A216721 2-15-67	During postcheckout final inspection, it was noted that 61 Deutsch bus modules, P/N's 1B57771-577, -561, -569, -559, -565, and -563, were suspected of being subjected to corrosion over an extended period of time due to insufficient primer between the polyurethane potting and the unplated surface of the modules.	The discrepant modules were reworked per salvage E.O. 1B57771-001. The rework instructions were to clean the area between the braze line and the potting with M.E.K. The cleaned area was painted with two coats of 1P20066 class 1 primer. The modules were identified as P/N 1B57771-001. The rework was acceptable to engineering.
A228138 10-25-66	During receiving inspection checkout of the J-2 rocket engine, P/N 103826, S/N J-2083, at the Space Systems Center, it was noted that the fuel turbine inlet temperature, channel 6 printout, read 6.653 vdc. The output of transducer, P/N NAS-27323T3, S/N 1159, should have been 0.000 to 0.400 vdc per 1B55471.	The discrepant transducer was removed and a new unit, S/N 560, was installed. Correct operation was verified per digital data acquisition checkout procedure 1B59500 D.
A228559 2-1-67	During final acceptance checkout at the Space System Center VCL, it was noted that the gas generator pressure transducer, P/N NA5-27412T10T, S/N 1383A, reference location 401-3MTP4, NASA measurement number D10, exceeded the requirements of Santa Monica Report SM46847. The noise level should not have exceeded 2.5 percent in 1 second, but was 2 to 3 percent for over 1 second.	The condition was acceptable to engineering.

TABLE II. STAGE RECEIPT TO FORMAL COUNTDOWN INITIATION

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A218924 3-28-67	<p>The following discrepancies were noted during receiving inspection:</p> <ul style="list-style-type: none"> a. The thrust structure Schraeder valve on the hydraulic air bottle was not safety wired. b. The cover was not installed on the auxiliary hydraulic pump port. c. The two unions on the LOX pump were not safety wired. d. Six cable clamps for the 404A4W1 cable assembly were not fastened to the mounting assembly, P/N 1058189. e. One bolt on each of the first three cold helium bottles was safety wired backwards. 	<p>a, c, and e. All hardware was safety wired per DPS 13300.</p> <p>b. The fitting and surrounding area was wiped clean with freon.</p> <p>d. The cable clamps were installed per blue print.</p>

TABLE II (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A229846 4-4-67	During prefire checkout, the following Deutsch connectors were found to be recessed out-of-tolerance. The allowable tolerance was 0.065 ± 0.015 in.	a through h. The discrepant contacts were removed and replaced per DPS 54002-10.
	a. Pin 10 of connector P13, at location 410A1J6, was 0.087 in. low.	
	b. Pin 5 of connector P5, at location 410A1J8, was 0.082 in. low.	
	c. Pin 11 of connector P5, at location 410A1J8, was 0.048 in. low.	
	d. Pin 4 of connector P3, at location 410A1J7, was 0.086 in. low.	
	e. Pin 10 of connector P12, at location 410A1J7, was 0.045 in. high.	
	f. Pin 10 of connector P7, at location 424A5J8, was 0.036 in. high.	
	g. Pin 10 of connector P10, at location 424A5J9, was 0.039 in. high.	
	h. Pin 11 of connector P10, at location 424A5J9, was 0.034 in. high.	

TABLE II (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A229848 4-6-67	During prefire modification, two wire supports, P/N's 1B57776-9 and 1B37428-51, on the signal conditioning panel, P/N 1B55689-1, were found to be broken. Reference locations were 411A61A201 and A206.	The broken supports were removed and replaced.
A241922 3-10-67	During receiving inspection, it was noted that the aft dust cover, P/N 1B61077-1, S/N 2, was torn in several places.	The tears were repaired per B/P requirements.
A241979 4-6-67	Approximately twenty metal particles were found in the Deutsch feedthrough connector during the LOX laboratory rework of the LOX tank instrumentation probe, P/N 1A69275-507, S/N 07.	The metal particles were satisfactorily removed by utilizing pressurized nitrogen, a lint free cloth, and freon PCA.
A241980 4-17-67	During the ambient temperature relief tests, the cold helium fill module, P/N 1B57781-501, S/N 0011, had a reseal pressure of 3195 psig. The reseal pressure should have been 3200 to 3500 psig.	The defective module was removed and replaced with a new unit, P/N 1B57781-503, S/N 0031.
A241985 5-1-67	During cleaning and checkout in the LOX laboratory, it was noted that the cold helium fill module, P/N 1B57781-503, S/N 0031, had a cracking pressure of 3180 psig. The cracking pressure should have been 3200 to 3500 psig.	The discrepant part was sent to the Santa Monica plant and tested per 1B57781 to confirm the discrepancy. An adjustment was made to the module to bring it within specifications. The module was re-installed on the stage.
A245444 4-7-67	The pneumatic power control module assembly, P/N 1B43657-509, S/N 016, malfunctioned twice during checkout at the Space Systems Center VCL. The regulator overpressurized and the backup pressure switch picked up each time and closed the control helium shutoff valve.	The discrepant module was removed and a new unit, S/N 022, was installed.

TABLE II (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A245445 4-21-67	During prefire checkout, it was noted that three level sensor control modules, P/N 1A68710-511, S/N's D37, D58, and D29, were unstable, intermittent, and could not be adjusted.	The three discrepant modules were removed and new units, S/N's D130, D91, and D76 were installed.
A245446 4-21-67	The center contact of pin 11 in plug J1 of the level sensor module, P/N 1A68710-511, S/N D76, was spread and caused an intermittent reading during checkout.	The discrepant module, S/N D76 was removed and a new unit, S/N D88, was installed.
A245447 4-25-67	During installation of the vent and relief valve, P/N 1A48257-509, S/N 0043, it was noted that the recessed area on the mounting flange was too small to allow installation of the valve. The recessed area should have been 1 in. minimum diameter with a 0.300 to 0.324 in. diameter hole in the center. The recessed area was 13/16 in. diameter.	The discrepant valve was returned to the vendor for rework and a new unit, S/N 0047, was installed.
A245478 4-14-67	During an inspection line check, it was noted that the rod ends of the actuator shafts of the pitch and yaw hydraulic actuators, P/N 1A66248-501, S/N's 56 and 57, respectively, were dinged around the periphery of the mid-stroke lock installation (recessed) area. This damage was due to the repeated removal and re-installation of the mid-stroke locks.	The scratches and gouges were deburred using crocus cloth and handstones. After rework the hydraulic actuators were accepted for use.
A245479 4-17-67	During checkout in the Space Systems Center VCL, the pneumatic power control module, P/N 1B43657-509, S/N 016, malfunctioned twice. The regulator overpressurized and the backup pressure switch picked up each time and closed the control helium shutoff valve.	The discrepant module was removed from the stage and routed to the Space System Center Material Review Control Center for further disposition. The replacement part, S/N 022, was installed per FARR A245444.

TABLE II . (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A245481 4-21-67	During the propulsion system leak and functional checks it was noted that the LH ₂ pressure redundant check valve, P/N 1B53920-201, S/N 051, had a reverse leakage of 8400 scim. The maximum allowable leakage was 6000 scim.	The discrepant valve was removed and a new unit, S/N 040, was installed. The new valve was tested per 1B70773.
A245484 4-24-67	During the propulsion system leak and functional checks it was noted that pipe assembly, P/N 1B64131-1, had a damaged flare mating surface.	The discrepant pipe assembly was removed and replaced with a new unit. System integrity was verified per 1B70773.
A245486 4-24-67	The center contact of pin 11 in plug J1 of the level sensor module, P/N 1A68710-511, S/N D76, was spread and caused an intermittent reading during checkout.	The defective module was removed from the stage and a new unit, S/N D88, was installed. The discrepant part was routed to the vendor for repair of the noted pin.
A245487 4-25-67	During installation of the fuel tank vent and relief valve, P/N 1A48257-509, S/N 0043, it was noted that the recessed area on the mounting flange was too small to allow installation of the valve. The recessed area should have been 1 in. minimum diameter with a 0.300 to 0.324 in. hole in the center. The recessed area was 13/16 in. diameter.	The discrepant valve was removed and a new unit, S/N 0047, was installed.
A245488 4-25-67	During the propulsion system leak and functional check, it was noted that pipe assembly, P/N 1B64131-1, had a damaged flare mating surface.	The discrepant pipe assembly was removed and replaced with a new unit.

TABLE II (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A245489 5-8-67	During stage checkout the following discrepancies were noted against the analog comparator, P/N 1A86991-1, S/N 00313. a. The comparator failed to trigger during the SIM automatic procedure. b. Potentiometer R-4 was loose and the printed circuit pins were not making good contact with the chassis connector.	a and b. The potentiometer R-4 was tightened and the unit retested. No electrical malfunctions were found and the comparator was accepted for use.
A245512 3-17-67	The reliability of spot welds on the fix mount sleeve, P/N 973500, of the LH ₂ mass sensor, P/N 1A48431-505, S/N D1, were suspected of faulty processing according to a Minneapolis Honeywell TWX, dated 3-7-67.	The LH ₂ mass sensor was removed from the stage, and the fix mount sleeve reworked per salvage FO 1A48431-009, which installed rivets in the spot weld areas. After rework the mass sensor was re-installed in the stage.
A245519 4-4-67	The following discrepancies were noted during modifications: a. Plugs J1, J2, J3, J4, and J5 on the 1B57693 -501 panel, reference location 404A61A204, were installed on the wrong side of the mounting bracket. b. Connectors, P/N 1B57771-551, and 1B57771 -559, on the 1B51375-513 panel, reference location 411A99A24, were not installed per B/P.	a and b. All connector mountings were acceptable to Engineering.

TABLE II (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A245520 4-7-67	During inspection surveillance the following discrepancies were noted on the helium storage tank, P/N 1A49990-505, S/N 14: a. A 6.5 by 0.001 in. scratch at plane "A", 14 in. from the harness boss and between 270 and 300 degrees from the zero reference line. b. Three parallel marks 10 by 0.0005 in. located 11 in. from plane "A", 6 in. from the harness boss and between 45 and 95 degrees from the zero reference line. c. A 7 by 0.001 in. scratch 14 in. from plane "B" 5 in. from the neck edge.	a, b, and c. All items were acceptable to engineering for use.
A245524 4-20-67	During prefire checkout and setup, three level sensor control modules, P/N 1A68710-511, S/N's D37, D58, and D29 were unstable and could not be adjusted.	The discrepant modules were removed and new units, S/N's D130, D91, and D76 were installed.

TABLE II (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A251426 4-11-67	<p>During the prefire checkout the following items were noted on the ambient helium sphere, P/N 1A49990-501-001, S/N 86:</p> <ul style="list-style-type: none"> a. No evidence of proof test after reworking per FARR A233767. The rework removed 0.0095 in. of material thickness, leaving a total thickness of 0.3345 in. Minimum thickness should be not less than 0.334 in. b. No evidence of dye check to determine if the original pit had been removed. c. The -001 part number (indicating that the sphere passed the eddy current test) was almost obliterated. 	<ul style="list-style-type: none"> a. A proof test was not required. Engineering prohibits reproof testing of spheres when material has not been reduced below minimum thickness. b. The reworked area was dye checked and no discrepancy was noted. c. The sphere was re-identified -001 by electro-chemical etching.
A251439 5-20-67	<p>During prefire checkout it was noted that the tap fitting port, P/N 1B29959-1, in the bulk-head vacuum system was sealed with 1P20057 sealant.</p>	<p>The tap fitting was removed from the stage and the sealant was peeled off using MEK. An inspection was made to ensure that the mating parts in the stage were open. After inspection and cleaning, the tap fitting was re-installed per 1A39307.</p>

TABLE II. (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A251440 5-22-67	<p>The following discrepancies were recorded against the LH₂ low pressure duct, P/N 1A49320-509, S/N 4, upper section:</p> <ul style="list-style-type: none"> a. The vacuum decayed from 8 microns to 200 microns in 48 hours. Maximum allowable decay is 100 microns in 10 days. b. A second 48 hour decay test indicated a decay of 27 microns. c. The third pump-down and decay test showed the decay, over a 72 hour period, to be within tolerance. 	The low pressure duct was accepted for use. The out-of-tolerance condition was due to entrapped GN ₂ .
A251441 5-22-67	The LOX pressure module, P/N 1B42290-503, S/N 0025, exhibited excessive leakage at 2500 scim through the cold helium shutoff valve. Maximum allowable leakage is 375 scim.	The discrepant module was removed from the stage and routed to the SSC MRCC for further disposition. A new unit, S/N 0037, was installed.
A251442 5-23-67	After replacement by the vendor of a burst disc and retainer, it was noted that the LH ₂ low pressure duct, lower section, P/N 1A49320-511, S/N 36R, would not maintain a vacuum. A decay test indicated a decay of 122 microns in 72 hours. Maximum allowable is 100 microns in 10 days.	After an additional pumpdown, the LH ₂ duct was accepted for use. Entrapped GN ₂ , used by the vendor during rework, gave the indication of leakage.

TABLE II. (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A251488 4-26-67	During a pin dimensional check per WRO-S-IV-B-334B-R4 the following discrepancies were noted against the Deutsch connectors, P/N D507-19-25-9, on the 411W11 wiring harness. Measurements from tip of center contact to open end of contact body should have been 0.065 \pm 0.015 in. a. Plug P2, Pin 10 was 0.113 in. b. Plug P4, Pin 10 was 0.091 in. c. Plug P10, Pin 11 was 0.089 in. d. Plug P11, Pin 10 was 0.095 in. e. Plug P12, Pin 10 was 0.041 in.	The discrepant pins were removed and replaced, with the exception of pin 10 in plug P12, which was acceptable for use.
A251493 5-1-67	During a pin dimensional check per WRO-S-IV-B-334B-R4 the following discrepancies were noted against the Deutsch connectors, P/N 1B37872-513, on the 404W208 wiring harness. Measurements from the tip of the center contact to the open end of contact body should have been 0.065 \pm 0.015 in. a. Plug P77, Pin 8 was 0.040 inches b. Plug P77, Pin 9 was 0.102 inches	a. Pin 8 in plug P77 was acceptable for use. b. Pin 9 in plug P77 was removed and replaced.

TABLE II. (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A251494 5-5-67	During the propulsion system leak checks the LH ₂ pressure redundant check valve, P/N 1B53920-501, S/N 051, exhibited a reverse leakage of 8400 scim, the maximum allowable leakage was 6000 scim.	The discrepant check valve was removed from the stage and sent to the Space Systems Center MRCC for investigation and final disposition. A new check valve, S/N 040 was installed.
A251498 5-10-67	During installation of the LH ₂ tank manhole mounting ring, it was noted that the ring assembly, P/N 1A39301-1, S/N 4, did not have a clearance hole drilled to accomodate the index pin on the mounting ring.	A blind clearance hole, 1/2 inch diameter by 1/2 inch deep was drilled in the ring assembly. The rework was acceptable for use.
A251499 5-11-67	<p>The following conditions were noted for the LH₂ mass probe, P/N 1A48431-505, S/N D1, during disassembly per 1A48431-505-009:</p> <ol style="list-style-type: none"> The retaining pin, P/N 970353-6, was installed with sufficient force to cause "peeling" of the pin, and to prevent removal of the pin without damage. The split-sleeve, P/N 1989963-1, could not be removed without using force, which resulted in damage to the part. The KEL-F plug remained forced into half of the split sleeve, P/N 1989963-1. This should have been a loose fit. The locking pin, P/N 97349-1, appeared to have been sawed off and rough filed. The hollow end of the above part contained a foreign rubber-like material. 	The discrepant LH ₂ mass probe was removed and a new unit, S/N D6, was installed.

TABLE II. (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A251516 5-12-67	<p>The following conditions were not acceptable to AFQAR:</p> <ol style="list-style-type: none"> Indicated output of expanded scale module, forward 2 (M68), was 4.96 vdc and should have been 5.00 vdc. Indicated output of expanded scale module, forward 1 (M24), was 4.97 vdc and should have been 5.00 vdc. 	<p>The discrepancy was resolved by changing the CAT-1 calibration curve and the data description tape curve from 4.5 to 5.5 vdc to a corrected value of 4.52 to 5.52 vdc. This change was acceptable to the MRB for use.</p>
A251537 5-17-67	<p>During flight critical items verification it was discovered that the LH₂ chilldown check valve, P/N 1B53920-503, S/N 042, was not identified with the part number, dash number, or change letter.</p>	<p>The check valve was removed from the stage, inspected for configuration; and identified with the part number, dash number and change letter per DPS 02303 "Electro-Chemical Etch". After completion of treatment of the etched area per DPS 41410 the part was cleaned per MSFC-SPEC-164 and re-installed in the stage.</p>
A251538 5-17-67	<p>During flight critical items verification it was noted that the LH₂ chilldown check valve, P/N 1B53920-503, S/N 042, was not identified with the part number, dash number or change letter.</p>	<p>The check valve was removed from the stage, inspected for configuration; and identified with the part number, dash number and change letter per DPS 02303 "Electro-Chemical Etch". After completion of treatment of the etched area per DPS 41410, the part was cleaned per MSFC-SPEC 164, and re-installed in the stage.</p>

TABLE II. (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A251540 5-19-67	<p>The following items were revealed by radio-graphic inspection per 1B40645:</p> <ul style="list-style-type: none"> a. A paper clip located 8-3/4 in. aft of the aft "V" section, between stringers 45 and 46, 3-3/4 inches from the center of stringer 45. Major axis of the clip was parallel to the major axis of the stage. b. Three inclusions, possibly aluminum chips, located 3-1/2, 3-3/8, and 3 in. aft of the aft "V" section between stringers 18A and 19. The inclusions were 1-1/2, 1-7/16, and 1/4 in. from the center line of stringer 19. Dimensions of the inclusions were 0.125 by 1 in., 0.175 by 0.050 in., and 0.150 by 0.050 in. <p>Further x-ray inspection, using a tangential (to the common bulkhead) exposure, revealed that the paper clip was imbedded in the honeycomb 36 degrees, 30 minutes from position III toward position II. The paper clip was 23.5 inches in from the outside wall of the aft skirt at station 280 and was oriented with its major axis parallel to the major axis of the honeycomb cells. The paper clip was a standard size clip, 1-5/16 by 5/16 in. with a wire diameter of 0.045 in.</p>	The noted conditions were accepted for use without rework.

TABLE II. (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A251541 5-19-67	During the leak and functional checks it was noted that the cold helium shutoff valve on the LOX tank pressurization control module, P/N 1B42290-503, S/N 0025, had a leakage rate of 2500 scim. The maximum allowable leakage was 375 scim.	The discrepant control module was removed and a new unit, S/N 0037, was installed.
A251542 5-20-67	During the digital data acquisition system checkout it was noted that the output of the channel decoder, P/N 1A74053-503, S/N 275, went into a high calibration mode when the run mode command was given. It should have gone into the high calibration mode only when the high calibration mode command was given.	The discrepant decoder was removed and a new unit, S/N 140, was installed.
A251543 5-22-67	During digital data acquisition system check-out it was noted that the output of the channel decoder, P/N 1A74053-503, S/N 275, went into a high calibration mode when the run command was given. It should have gone into the high calibration mode only when the high calibration mode command was given.	The discrepant channel decoder was removed from the stage and routed to the Space Systems Center MRCC for further disposition.
A251545 5-22-67	While running the engine sequence portion of the propulsion automatic system test it was noted that the gas generator timing was too slow. The gas generator timing average for 10 operations was 128 milliseconds and should have been 140 milliseconds. The gas generator control valve orifice of 0.047 in. diameter was too large.	The 0.047 in. orifice was removed from the engine and replaced with a 0.043 in. diameter orifice. The rework was acceptable for use.

TABLE III. COUNTDOWN INITIATION AND POSTFIRE CHECKOUT

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A251592 6-15-67	<p>The following discrepancies were noted during test run 1046:</p> <p>a. After cryogenic loading, the LH₂ chilldown duct, P/N 1A49966-503, S/N 023, had a vacuum reading of over 1000 microns and should be less than 250 microns. The vacuum reading taken during task 7 of the countdown was 7 microns.</p> <p>b. The vacuum reading on the LH₂ low pressure duct, upper section, P/N 1A49320-509, S/N 44, was over 1000 microns and should be less than 250 microns. The vacuum reading taken during task 7 was 5 microns.</p>	<p>a. The discrepant LH₂ chilldown duct was removed and a new unit, S/N 026, was installed.</p> <p>b. The discrepant LH₂ low pressure duct was removed and a new duct, P/N 1A49320-501, S/N 45, was installed.</p>
A255204 6-20-67	During postfire checkout the cold helium fill module, P/N 1B57781-503, S/N 0031, froze in the open position.	The discrepant module was removed and a new unit, S/N 0034, was installed.
A255205 6-21-67	During postfire checkout the cold helium fill module, P/N 1B57781-503, S/N 0031, froze in the open position.	The discrepant module was removed from the stage and returned to the vendor for rework. A new unit, S/N 0034, was installed.
A255206 6-21-67	During acceptance static firing at plus 604 seconds channel D050, the engine pump purge transducer, P/N 1B43320-511, S/N 21.1, at reference location 403MT600, became erratic in operation, and at 612 seconds the channel output indicated -9.0 psia. Conditions at this time were at ambient pressure, 14.7 \pm 3 psia.	The discrepant transducer was removed and replaced.

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TABLE III. (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A255210 6-26-67	During static firing, the output of the LOX pressure module regulator was 222 to 230 psia after mainstage and should have been 410 \pm 25 psig.	The discrepant part was removed and routed to Santa Monica MRCC for test and evaluation. A new unit, S/N 0028, was installed.
A255211 6-26-67	<p>The following discrepancies were noted against the LOX pre valve, P/N 1A49968-509, S/N 101, during static firing:</p> <p>a. When the pre valves were cycled, no hard-wire talkback was received from the LOX pre valve. After cycling talkback was received.</p> <p>b. Opening time for the LOX pre valve was 3.010 seconds by comparison to 2.595 seconds for the LH₂ pre valve. Operating times for the pre valves should be within \pm 0.010 seconds of one another.</p>	The discrepant LOX pre valve was removed from the stage and routed to Santa Monica MRCC for test and evaluation. A new unit, S/N 109, was installed.
A255212 6-27-67	After cryogenic loading for test run 1046 it was noted that the LH ₂ chilldown duct, P/N 1A49966-503, S/N 023, had a vacuum reading of over 100 microns. A vacuum reading taken during pre-countdown activities was 9 microns. The specification is 250 microns maximum loss in 30 days.	The discrepant duct assembly was removed from the stage and routed to Santa Monica MRCC for investigation. A new unit, S/N 026, was installed.

TABLE III. (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A255213 6-27-67	After cryogenic loading for test run 1046 it was noted that the LH ₂ feed duct, P/N 1A49320-509, S/N 44, had a vacuum reading of over 1000 microns. The duct was pumped down to 10 microns. Three days later the reading was again over 1000 microns. The maximum vacuum loss should be less than 250 microns in 30 days.	The discrepant duct assembly was removed from the stage and routed to Santa Monica MRCC for investigation. A new unit, S/N 45, was installed.
A255214 6-27-67	This FARR superceded FARR A251597 which reworked the following conditions on the LH ₂ lines: <ul style="list-style-type: none"> a. The proseal adhesive was found to be loose around both edges of the foam seal, P/N 1B39506-1. b. The polyurethane coating was cracked in the same location as above. Seal, P/N 1B39506-1, was also split for a length of 1-1/4 in. at the 1 o'clock position. 	<ul style="list-style-type: none"> a. The loose proseal adhesive was removed. The metal surface was prepared per DPS 30000 and all zinc chromate was removed from the faying surfaces. The seal was then re-cemented with proseal 501 per DPS 22301. b. The polyurethane coating and foam seal was repaired with polyurethane cable molding by filling all cracks and then curing the filled areas for 2 hours at 150 to 190°F. <p>The rework was acceptable for use.</p>
A255275 7-7-67	During static firing the engine pump purge pressure transducer, P/N 1B43320-511, S/N 21-1, NASA measurement D050, became erratic at +604 seconds. At +612 seconds it read -9.0 psia. At ambient it read -6.0 psia. It should have read 14.7 psia.	The discrepant transducer was removed from the stage and replaced.

TABLE III. (Continued)

<u>FARR NO.</u>	<u>DESCRIPTION OF DEFECTS</u>	<u>DISPOSITION</u>
A255452 8-22-67	During postfire checkout in the STC VCL it was noted that the LOX pressure control module, P/N 1B42290-503-001, S/N 0028, was a "not for production use" part. The module was not identified per the requirements of SEO 1B42290-001B; which required marking the module "not for production use".	The module was removed from the stage, identified as "test" with 1/4 inch letters per DPS 02003 and was returned for a "test only" part.



MISSILE & SPACE SYSTEMS DIVISION/SPACE SYSTEMS CENTER
5301 BOLSA AVENUE, HUNTINGTON BEACH, CALIFORNIA
A DIVISION OF DOUGLAS AIRCRAFT COMPANY, INC.